Submitted to:
US EPA Region 8
Denver, CO

Submitted by:
Atlantic Richfield Company
Anchorage, AK
May 2, 2011

1194020

Source Control Documents

Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01 Rico, Colorado

Atlantic Richfield Company

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May 2, 2011

Mr. Steven Way
On-Scene Coordinator
Emergency Response Program (8EPR-SA)
US EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129

Subject: Source Control Documents
Rico-Argentine Mine Site – Rico Tunnels
Operable Unit OU01 Rico, Colorado

Dear Mr. Way,

Please find enclosed three (3) copies of the *Source Control Documents* dated May 2, 2011. Atlantic Richfield is submitting the documents in accordance with Section 5.5.1 of the Removal Action Work Plan, Rico-Argentine Mine Site – Rico Tunnels, Operable Unit OU01 Rico, Colorado dated March 9, 2011. In the interest of providing EPA with a timely submittal for the upcoming May 10 meeting, this submittal includes all documents currently available to Atlantic Richfield Company that are believed relevant to at least some degree to the source control issue.

If you have any questions, please feel free to contact me at 406.491.1129.

Sincerely,

Chuck Stilwell, P.E.
Project Manager
Atlantic Richfield Company

Enclosures

cc: R. Halsey, AR
S. Dischler, AR
T. Moore, AR
C. Sanchez, Anderson Engineering
T. Kreutz, AECOM (w/o encl.)
D.Yadon, AECOM (w/o encl.)
J. Decker, AECOM (w/o encl.)

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1974, USGS Professional Paper 723, Plate 2 – *Maps Showing Geology of Nos. 4, 5 and 6 Levels of Yellow Jacket Mine and Some of Geology in CHC Hill, Rico District, Colorado*

Undated, St. Louis Smelting and Refining Co., *Composite Map of Mine Workings in St. Louis Tunnel Area*

March 1929, St. Louis Smelting and Refining Co., *Wellington Mine*

1-Rico Mine Water Memo – 10-20-05

MEMORANDUM

TO: Chuck Stilwell, PE

FROM: Douglas M. Yadon, PE/SEH; Terry P. McNulty, PE/TPMA

DATE: October 20, 2005

RE: Rico Mine Water Inflow/Loading Reduction - Meeting Summary and Recommended Action Plan
SEH No. A-ARCOE0105.00/30000

The following is a summary of thoughts exchanged and tentative conclusions drawn during a September 23, 2005 meeting held in the 3rd Floor conference room of the Denver office of Davis Graham and Stubbs (DGS). Doug Yadon of SEH and Terry McNulty of TPMA were the primary participants and Steve Marlin and Adam Cohen of DGS attended and contributed periodically. Chuck Stilwell participated by conference call at the beginning and at the end of the meeting. The objective of the meeting was to assess available documents, then to develop a plan for (1) evaluating ways of reducing fresh water ingress into the underground workings, and (2) identifying potential avenues for reducing metal loadings in water discharging from the St. Louis Tunnel.

DEVELOPMENT OF OPTIONS

In the spirit of considering all reasonable possibilities, the following options were introduced and discussed.

A. Deep Well Injection: The discharge from the St. Louis Tunnel would be captured and pumped down a deep lined well and perforated in a zone with sufficient porosity and permeability to absorb and retain the water and its dissolved solids. Assistance from a groundwater hydrologist would be essential and a detailed study of subsurface geology would be required. The core logs from Anaconda's 1980s molybdenum exploration program would be helpful. (These logs are not in SEH's or TPMA's files; they may be included in the Anaconda collection at the University of Wyoming in Laramie.) If preliminary evaluation proved encouraging, a test well should be considered.

B. In-Mine Diversion and/or Treatment: A detailed examination of mine maps and geology/mineralogy could enable us to identify target mineralized zones and to develop some approaches that might be taken. Examples include underground bulkheads, local tunnel lining or piping of flows, and treatment by cation adsorption, e.g., with "Kitty Litter", and periodic removal of loaded adsorbent.

C. Isolation of Pyrite Zones: The underlying thought is that we know that oxidation of pyrite is producing ferric sulfate and sulfuric acid, causing oxidation of nonferrous metal sulfides and dissolution of those metals along with non-sulfide metals like manganese. The pyrite that is being oxidized could be disseminated grains that accompany the primary lead/zinc mineralization. Or, the pyrite source may be the remnants of the very pure pyrite mined during the 1950s for roasting on-site to produce sulfuric acid. In the latter case, the other metals may simply originate as minor accessory minerals to the pyrite. We suspect that the pyrite was mined from stopes that were near the level of the St. Louis Tunnel and therefore well below most of the other workings. If so, perhaps the pyrite zones could be isolated and rendered inaccessible to water. A study of historical mineral production, e.g., USGS annual publications of *Mineral Resources of the U.S.*, as well as Rico Renaissance records, would shed light. Encouragement at this point would lead to consideration of underground reconnaissance.

D. Elimination of Oxygen Supply: If exposure of underground sulfides to oxygen could be eliminated, formation of sulfuric acid and soluble metals would cease. The oxygen dissolved in surface water, roughly 3 ppm at 9,000 feet elevation, is inconsequential to sulfide oxidation, so the culprit is atmospheric oxygen. The applicable reaction is as follows:

$$2FeS_2 + H_2O + 7.5O_2 = Fe_2(SO_4)_3 + H_2SO_4$$

In nature, the reaction is almost always catalyzed by the microbe, *thiobacillus ferro-oxidans*, but the microbe needs oxygen too. According to this reaction, one mole of iron consumes 3.75 moles of oxygen. A flow rate of 600 GPM with a total iron loading of 200 ppm (a guess) equates to 1.00 pound of total iron per minute, or 0.018 pound moles per minute, requiring 0.067 pound moles of oxygen. This would be 24 SCFM of oxygen or 115 SCFM of air. However, very little of the oxygen in flowing air is utilized by oxidation of underground minerals, and a reasonable guess is 10 percent, suggesting a requirement of around 1,100 SCFM of air. We recall that a 1970s report included an air velocity measurement of 22 feet per minute in the Blaine Tunnel. Given an 8-foot square opening, this suggests a flow rate of about 1400 CFM; correction for altitude yields roughly 970 SCFM, indicating that the orders of magnitude are reasonably close. (The point of this exercise was simply to ascertain if the likely total flow is in the tens, hundreds, or thousands of CFM.) One would expect a chimney effect with inflow at lower levels feeding an updraft. We do not yet know if there are openings above the Blaine portal. Perhaps installing sealable doors on all open tunnels and shafts would exclude a majority of the air that passes through the workings.

E. Segregate the Water Descending from the Blaine Level Through the No. 3 Shaft: The data that we have reviewed thus far do not provide consistent values for pH and metal loadings, but there is some evidence that the flow onto the Blaine level is acidic and that it contains iron and other metals. Further examination may indicate some merit in segregating the Blaine level and this can be accomplished by simply removing the plug from a bulkhead that is roughly 600-800 feet south of the Blaine portal. Currently, the bulkhead dams water so it can flow into the Number 3 Shaft, thence downward to the St. Louis level. However, this may require having to capture and treat the Blaine discharge separately, unless one or more of the other methods discussed herein resulted in discharges of sufficiently low metals loading. Additional data on the Blaine discharges is apparently forthcoming from Adam Cohen's search of CDPHE records and will be reviewed upon receipt.

F. Control the Inflow of Clean Water

We could seek and identify openings, either shafts or tunnels, draining large watersheds, a cluster of shafts in a valley being an ideal example. Also, we know that the Blackhawk Fault that controls mineralization in the northern part of the district has a surface or near-surface expression for several miles of strike length. Various reports indicate that a substantial inflow of water derives from the fault. Perhaps the fault could be paved or a diversion ditch could be excavated on the uphill side. Also, the fault cuts through the Silver Creek drainage. If it is receiving water from the creek, it may be possible to divert the creek temporarily, expose the fault, and grout it or otherwise seal it.

G. Plugging of Openings with Accompanying Rise of Internal Water Level
We discussed the possibility of installing a tight door on the St. Louis Tunnel, plugging openings above the St. Louis level, and allowing the water to rise. Submergence of sulfides would prevent oxidation and rising water would decrease inflow. Obviously, this approach presents potential risks that must be carefully assessed. We would need a comprehensive catalog of openings, their GPS coordinates, and their surface elevations in order to establish spatial relationships. We would also need a groundwater map and a groundwater hydrologist's assessment of likely response of the groundwater system. In a perfect world, we might be able to establish an equation for height of the impounded water surface versus inflow.

PROPOSED ACTION PLAN

Evaluation of any or all of the potential options for reducing water inflows and/or metals outflows identified above will require certain additional information, resources, action(s), and ultimately confirmation if the option is to be further pursued. The overall plan for each option is summarized briefly in the following table:

OPTION	INFO NEEDS	RESOURCE	ACTION	CONFIRMATION
A	Anaconda core logs	Participation of a groundwater hydrologist	Develop a geohydrologic model	Drill and operate a test well
B	Mine maps/geology and water assays	Mine geologist or good substitute	Identify targets and locations	Install diversions and test treatment alternatives
C	Production history and geology by level	Geochemist and an underground miner	In-mine recon and "ground truthing"	Isolate a test zone and monitor discharge
D	Catalog of openings and locations, field airflows	Field technicians	Determine feasibility of sealing openings	Seal most significant holes and measure effect
E	Status of bulkhead and water analyses, flow rate	Underground miner	Determine effect of segregation	If remaining water clean, segregate/treat Blaine only
F	Same as D, but no airflows needed	Groundwater hydrologist plus a geotechnical engineer	Determine feasibility of diverting water	Test and assess effects
G	Same as D	Groundwater hydrologist	Produce a groundwater map/model	Evaluate potential response of groundwater system

A phased approach to further evaluation of the identified options is proposed. This approach is intended to compile in an appropriate format and preliminarily evaluate available information relevant to each of the options as a basis for deciding if further effort on a given option is warranted. Based on the collection and initial review of data to date, the following specific Phase I tasks are proposed:

1. Additional information: Collect and review existing published or unpublished data or information not already compiled and initially reviewed. This includes, but is not necessarily limited to published mine production data from the U.S. Geological Survey and, if available, drilling logs and related data for the deep molybdenum exploratory borings by Anaconda.

2. Mine openings map: Prepare a map on a suitable topographic base with the locations of all known existing and historic openings to the surface, including tunnels, shafts, and adits, and selected internal workings known or suspected to encroach near to the surface.

3. Preliminary mine workings/ore deposits model: Compile in map, section and/or database format an initial summary of known or suspected locations of ore (in place or mined out) or otherwise highly mineralized deposits within the historic mine workings. Coordinate locations with mine openings map under Task 2. Note that detailed compilation of ore/mineralized areas would follow under Phase II if appropriate.

4. Conceptual hydrogeologic model: Develop a conceptual hydrogeologic model of the Telescope Mountain – Silver Creek – Newman Hill area based on available geologic and geohydrologic mapping and data as a basis for assessing potential groundwater response to changes in existing conditions (e.g., plugging mine openings, reducing permeability of natural conduits such as fault zones, etc.).

5. Water quality/flow database: Compile a water quality and flow database from available data that is specific to the options previously described. This would include all available data on St. Louis Tunnel and Blaine Adit discharges, and any internal estimated or measured flows (and water quality results, if available).

6. Preliminary evaluation and screening of options: Evaluate each of the seven (7) options identified previously based on the information compiled and reviewed under Tasks 1-5 above. Identify key issues associated with each option, including data gaps, technical feasibility, regulatory constraints, etc. Screen and prioritize options for further study (if any). If one or more options appear sufficiently promising, a specific work plan to further evaluate the option(s) would be prepared and submitted to Atlantic Richfield for review and authorization.

We propose to utilize the services of W. Roger Hail, PG and/or Patrick C. Plumley, PG during Phase I for consultation on groundwater hydrology and mining geology. If necessary, SEH and TPMA will also identify and engage the services of a geochemist and/or economic (ores) geologist, subject to the concurrence of Atlantic Richfield.

Please let us know if you have any questions or would like to discuss any of the information or proposed approach in this memo. Unless we hear otherwise, we will proceed with Tasks 1-6 of Phase I described above under the current remaining authorization for Work Release No. 30 in order to keep the process moving forward. Upon your concurrence or alternative direction on this proposed approach, we will prepare a request for an amendment of the scope and budget for Work Release No. 30 as necessary and appropriate to complete the work.

c: Terry P. McNulty, PE

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2-Rico Inflow-Loading Reduction – Text and Figures

- ~~Depending on the results of the investigative boring, enlarge this pilot bore and install a permanent pipe drain sized to prevent build-up of head within the tunnel/CHC Hill; construct pipe with a vertical riser as the pressure control measure, and provide means to convey any flows/solids discharging from the drain pipe to the ponds system.~~
- ~~Evaluate the need and practicality of constructing a surge basin in the collapse area as a back-up to detain flows and drop out solids should a blow-out occur even with the pressure control measures noted above.~~

~~2.5.1.3 Preferred Alternative~~

~~As noted in Section 2.5.1.3 the evaluation of this issue is ongoing and a preferred alternative has not yet been identified.~~

2.5.2 Inflow/Loading Reduction

2.5.2.1 Issues/Objectives

The St. Louis Tunnel is a major mine opening in a complex of interconnected mine workings in Telescope Mountain/CHC Hill to the northeast and Dolores Mountain (beneath the Silver Creek Valley) to the southeast. As shown in plan view on Figure 12, “Mine Workings/Geologic Structure Plan”, these interconnected mine workings are intersected by several major bedrock faults. Figure 13, “Mine Workings Profile”, shows that the St. Louis Tunnel is the lowest elevation mine opening among the interconnected workings. Also shown on Figures 12 and 13 are known historic and/or still present surface mine openings (adits, shafts, vents) that connected to the underground workings.

The underground mine workings, surface mine openings, and geologic structures together represent a complex, relatively high permeability “aquifer”. This aquifer is inferred to receive recharge from several sources: regional groundwater within Telescope Mountain and Dolores Mountain that is upgradient of the mine workings and the Blackhawk fault zone (which appears to form an effective high angle aquitard parallel to and among many of the workings); direct precipitation (rain, snowmelt) infiltrating down through joints and fractures in the bedrock overlying the mine workings, especially adjacent to the Blackhawk fault zone within which much of the mineralization in this part of the Pioneer District occurs; and possibly infiltration through inferred permeable interconnections at the nexus of the channel bottom of Silver Creek, immediately underlying mine workings (including the 517 and Argentine shafts which appear to connect these local workings to the St. Louis Tunnel southeast crosscut), and interconnecting high-angle joints and fractures associated with the Blackhawk fault zone that passes through this area.

The underground mine openings have transected both barren to somewhat mineralized host rock and locally high grade (very metaliferous) ore zones/bodies. The exposed surfaces in the mine workings (and along joints and fractures in the surrounding rock), especially in ore-grade reaches (even if much of the ore was mined out) are presumed sources of metals loading to the groundwater draining through the workings where there is sufficient oxygen to result in dissolution of the metals from the ore or host rock.

The interconnected underground mine workings, together with the intersecting geologic structure (faults and associated joints and fractures) result in the St. Louis Tunnel functioning as a very effective groundwater drain for this portion of the Pioneer Mining District. This groundwater is characterized by elevated dissolved metals concentrations as a result of groundwater flows over metaliferous rock in the presence of adequate oxygen. The accumulated metals-bearing groundwater discharges from the St. Louis Tunnel and is then routed through the St. Louis Ponds System. Reducing or eliminating these groundwater discharges and/or associated dissolved metals loadings would result in proportionate reductions or elimination of the need to treat water at the St. Louis Ponds site.

An ongoing evaluation of the potential to reduce or eliminate St. Louis Tunnel mine water discharge flows and/or associated metals loadings is summarized in the following subsections.

2.5.2.2 Alternatives Considered

A wide range of possible alternative measures to reduce or eliminate tunnel discharges and/or the associated metals loadings were initially identified and evaluated. These alternatives are briefly described as follows.

Alternative 1 - Deep Well Injection. Under this alternative the discharge from the St. Louis Tunnel would be captured and sent down a deep cased well perforated in a zone or zones with sufficient porosity and permeability to absorb and retain the injected water and its dissolved solids. Any such well would have to be thoroughly sealed through any aquifers with water quality supporting existing beneficial use or that could support potential future groundwater development.

A brief review of available geologic information suggests that conditions are not generally favorable for hydraulically efficient and cost effective deep well injection. Exploratory borings within the St. Louis Ponds site drilled by Anaconda in the early 1980s encountered hot, saline, mineralized water at depths believed to be up to several thousand feet. Although favorable in terms of in situ water quality for injection of mine drainage water, this deep aquifer is under significant pressure as evidenced by ongoing leakage at the surface of three of these borings that were abandoned and presumably sealed many years ago. Overcoming this natural pressure would require a pumped versus gravity injection system, and would present significant challenges dealing with the effects on well materials of the hot, corrosive groundwater encountered. Any aquifer with adequate permeability above the geothermal aquifer may be classified as a potential groundwater resource and not suitable for injection of metals-bearing water.

Further consideration of this alternative would require extensive hydrogeologic study at significant cost, including drilling deep test wells, performing sophisticated in situ tests of aquifer properties, and sampling and analysis of natural groundwaters encountered. The cost for such a program could be in the range of several hundred thousand dollars.

Alternative 2 - In-Mine Diversion and/or Treatment. This alternative envisions identifying and targeting the locations of more highly mineralized zones in the underground openings that would then be addressed by one or another of the following measures: underground bulkheads, local tunnel lining and/or piping to divert groundwater flows around mineralized zones; and/or in-mine treatment at accessible locations by cation adsorption with periodic removal of metals-loaded adsorbent. A detailed examination of mine maps and references on the geology/mineralogy of this portion of the Pioneer District available for review concluded that targeted mineralized zones could not be reliably identified beyond assuming that areas that had been mined out (when shown on the available very incomplete mine mapping) were sources of remaining high mineralization (which may or may not be the case).

As discussed in Section 1.3.2, the portal area of the St. Louis Tunnel is collapsed and the tunnel is no longer accessible from the adit. Access from the historically connected and apparently still open Blaine Tunnel portal may be possible, but conditions within the tunnel and especially in the interconnected deeper workings are uncertain but judged likely poor given their age and the absence of maintenance for at least the past 25 years. It is very unlikely that any of the shafts connecting the various working levels are still functional (if they are open and/or the hoists are even still present). Review of other historic information indicates that there are numerous areas in the underground workings that have caved and are thus no longer accessible without extensive rehabilitation.

On the basis of evaluations to date, this alternative appears highly problematic first due to the presumed very high cost to explore and rehabilitate the underground workings to a safe entry condition, and then the challenge of identifying and effectively isolating a sufficient number of mineralized zones to significantly impact metals loadings. A recent report (Associated Geosciences, Ltd., 2007) estimated on a very preliminary basis that rehabilitation costs to stabilize the still at least partially open Blaine and Argentine Tunnels adjacent to Silver Creek would be in the range of $2,000,000-$5,000,000.

Alternative 3 - Isolation of Pyrite Zones. The underlying thought supporting this alternative is that oxidation of pyrite within the underground workings is producing ferric sulfate and sulfuric acid, in turn causing oxidation of nonferrous metal sulfides and dissolution of those metals along with non-sulfide metals like manganese. The pyrite that is being oxidized could be disseminated grains that accompany the primary lead/zinc mineralization. Or, the pyrite source may be the remnants of the very pure replacement-type pyrite ore bodies mined during the 1950s and 1960s for roasting on-site to produce sulfuric acid. In the latter case, the other metals may simply originate as minor accessory minerals to the pyrite.

Based on review of available information, it appears possible (but not at all certain) that the more pure pyrite was mined from stopes that were near the level of the St. Louis Tunnel and therefore well below most of the other workings. If so, then such pyrite zones would be targeted to be isolated and rendered inaccessible to the mine discharge water. However, this alternative shares the same substantial challenges as identified above for In-Mine Diversion and/or Treatment, that is, the uncertainty in locating the remaining high-grade pyrite deposits and the cost to stabilize and rehabilitate the underground workings.

Alternative 4 – Reduction or Elimination of Oxygen Supply. If exposure of underground sulfides to oxygen could be significantly reduced or eliminated, formation of sulfuric acid and soluble metals would be substantially reduced or cease. The oxygen dissolved in surface water is typically inconsequential to sulfide oxidation. (Measured values of dissolved oxygen (DO) at the St. Louis Ponds System range from about 5-7 ppm in the near surface pond water, decrease to about 3-6 ppm at the bottom of the pond water, and are even less in the pore water in the treatment solids, in the range of 1-3 ppm typically). Thus, the driver is atmospheric oxygen. The applicable reaction is as follows:

$$2FeS_2 + H_2O + 7.5O_2 = Fe_2(SO_4)_3 + H_2SO_4$$

In nature, this reaction is almost always catalyzed by the microbe, *thiobacillus ferro-oxidans,* but the microbe needs oxygen too. According to this reaction, one mole of iron consumes 3.75 moles of oxygen. A flow rate of 600 gallons per minute with a total iron loading of 200 ppm (an assumed value) equates to 1.00 pound of total iron per minute, or 0.018 pound moles per minute, requiring 0.067 pound moles of oxygen. This would be 24 SCFM of oxygen or 115 SCFM of air. However, very little of the oxygen in flowing air is utilized by oxidation of underground minerals, and a reasonable estimate is 10 percent, suggesting a requirement of around 1,100 SCFM of air. An air velocity measurement of 22 feet per minute has been previously measured in the Blaine Tunnel (***add reference***). Given an 8-foot square opening, this suggests a flow rate of about 1,400 CFM; correction for altitude yields roughly 970 SCFM, indicating that the orders of magnitude are reasonably close. It is also possible that a "chimney effect" is present at least locally within the workings with inflow at lower levels feeding an updraft.

As noted previously, several openings were found that are presumably allowing air entry to at least some portion of the underground workings. These include the St. Louis, Argentine, Blaine and Wellington Tunnels, the Argentine Adit, and two ventilation (?) pipes in the vicinity of the Blain and Argentine Tunnels. *** other potential openings on the south slope above Silver Creek were not accessed on the initial reconnaissance and should be checked to determine if openings are present. Given the known and potentially more widespread caving of the underground workings, the extent and rate of air entry to the workings is unknown. No noticeable air movement was detected at the openings found during the reconnaissance.

Further evaluation is recommended of the potential for reducing or eliminating any significant air entry to the interconnected underground workings that may be occurring. Installing air doors or permanent air seals at all of the known and potential air entry points (except the St. Louis Tunnel) could be done for relatively low cost as adequate access is available to most of these features and no entry into the underground workings would be required. Although a cost estimate has not yet been developed, it is estimated that the cost of this work would be in the order of magnitude of tens or hundreds of thousands of dollars (rather than millions of dollars). Note that the St. Louis Tunnel is not included in this estimate for two reasons: 1) an air seal at this location would have to be designed so as not to impede the drainage of mine water from the adit (for reasons discussed later); and 2) very significant work would be required to clean-up and stabilize the existing collapsed portal area before a suitable air door with water passage could be installed.

Alternative 5 - Segregation of Water Descending from the Blaine Level through the No. 3 Shaft. There is evidence that minor flows from the Blaine Tunnel as analyzed in 1990, 2000 and 2001 were very acidic (pH 1.97-3.63) as compared to pH 6.6-7.4 for what are assumed to have been tunnel discharges measured in 1977, 1978 and 1985. All of these discharges, especially those at very low pH, contained elevated concentrations of dissolved iron and other metals. An internal bulkhead reportedly constructed in **** approximately 600-800 feet from the Blaine Tunnel portal backs up water that would otherwise discharge from the tunnel so that it instead flows into the No. 3 Shaft, thence downward to the St. Louis level (based on review of available historical correspondence, mine maps and verbal reports from miners hired by Atlantic Richfield Company to repair the bulkhead in late 2001). No data on flows from the Blaine Tunnel prior to bulkheading and diversion of flow down the No. 3 Shaft or of flows into the No. 3 Shaft since bulkheading have been found. The only flow data relative to the Blaine Tunnel encountered to date appears to be leakage past the bulkhead that was ultimately stopped by repairs made by Atlantic Richfield Company in 2001.

The impact of the total metals loadings from the flows currently intercepted at the bulkhead and diverted to the St. Louis Tunnel via the Blaine No. 3 Shaft on the total loads in the discharge from the St. Louis Tunnel are unknown. If the current flows down the No. 3 Shaft are as low pH as previously measured bulkhead leakage flows, and if flow rates are in fact significantly greater than the few gallons per minute (gpm) measured for the bulkhead leakage, then the impact of the Blaine flows diverted to the No. 3 Shaft on St. Louis Tunnel discharge metals loadings could be significant. However, if high flows of very low pH from the Blaine workings were in fact entering the St. Louis Tunnel it would be reasonable to expect significantly lower pH in the St. Louis Tunnel discharge than has been consistently measured over the past nearly 30 years (i.e., typically pH 7 or greater). The only alternative (and judged unlikely) explanation would have to be very substantial and efficient buffering by local limestone/dolomite beds in the underground workings traversed by the combined Blaine/St. Louis flows.

Further evaluation of this alternative may be warranted, but would first require making safe entry into the Blaine Tunnel to measure or at least estimate total flow diverted to the No. 3 Shaft and sample the flow for appropriate chemical analysis. Several sampling events during different seasons are recommended to get a sense of the variability in flow rate and water quality that may occur. If such data were collected and analyzed, a more informed decision could be made as to the potential merits of segregating the Blaine level flows from the St. Louis Tunnel flows. Segregation of these flows could presumably be accomplished by modifying the existing bulkhead to capture and convey the Blaine discharge to a separate treatment system (possibly a passive system depending on flow rates, existing water quality, and discharge water quality goals or requirements). Another concept that could be explored would be to add lime to the Blaine flows at the point they enter the No. 3 Shaft. To be effective, the lime addition would have to be done in a way to ensure thorough mixing. Either of these options would require permanently stabilizing and making safe at least the first approximately 1000 feet of the Blaine Tunnel as it was recently reported to be in “poorer condition that anticipated” (Associated Geosciences, Ltd., 2007).

Alternative 6 - Controlling Inflow of Surface Water. The objective of this alternative would be to prevent to the maximum degree feasible the introduction of “clean” (low metals concentrations) surface water into the underground workings and eventually to the St. Louis Tunnel. A surface reconnaissance based on a thorough review and compilation of historic surface mine openings was conducted to identify surface mine openings that were capable of receiving significant inflows of surface water. No openings were found that would intercept other than very minor direct precipitation or very localized surface runoff.

As noted previously in Section 2.5.2.1, the Blackhawk Fault controls mineralization in the northern part of the Pioneer District and many of the stopes from which the majority of ore was recovered occur within or adjacent to this fault zone. The Blackhawk Fault has a surface expression for several miles of strike length, suggesting the possibility that the fault zone may be characterized by a relatively high degree of associated high-angle jointing and fracturing. Such discontinuities could provide fairly efficient pathways for direct precipitation (primarily snowmelt) to reach the intersected underground workings. If infiltration rates along the fault zone were high enough, and if zones of jointing/fracturing could be reliably identified and characterized, then an alternative to consider might involve grouting and/or paving the near surface portion of the fault zone. However, a number of considerations suggest that this may not be practical or effective.

First, it does not appear that local surface water runoff to the fault zone is significant over the large majority of the known length of the fault, such that only direct precipitation is likely to enter the presumed jointed/fractured rock along the fault. Second, very approximate estimates of the annual infiltration from direct precipitation along most of the fault zone are low relatively to the measured St. Louis Tunnel discharges. Third, grouting and/or paving of several miles of the fault zone would be very challenging given the rugged terrain traversed, and would require implementation of significant environmental controls and mitigation. Finally, although a cost estimate has not been made, it is judged likely that the cost to implement such an alternative would greatly exceed the anticipated value of any benefits derived.

The one location where it may be worthwhile further investigating this alternative is at the nexus of Silver Creek, the Blackhawk fault zone, and the extensive Argentine and Blaine underground workings. In the absence of actual data to the contrary, it appears reasonable to theorize that some portion of the flow in Silver Creek seeps vertically downward through the inferred highly permeable, relatively shallow alluvium in the creek bed, into joints and fractures within the underlying bedrock within the Blackhawk fault zone, and then into various existing mine openings eventually working its way down to the St. Louis Tunnel level. One reason to consider further pursuing at least an investigation of this option is that if flows to the workings are in fact relatively high by this mechanism (even if only seasonally), mitigating such flows appears much more practical than any of the other alternatives involving access to the underground workings (or sealing the entire length of the Blackhawk fault zone). Further investigation, if pursued, should consider: 1) trying to measure losses by stream gaging immediately above and below the fault zone; and 2) observing, and to the degree feasible quantifying, losses with a dye tracer study. Although theoretically valid, both of these methods are constrained in terms of the precision of the measurements that can be practically made, and thus of the results derived. If mitigation appears beneficial in this area it would presumably involve: temporary diversion of Silver Creek around the work area; removal of alluvium/talus in the creek bottom and banks; blanket grouting of joints and fractures in the underlying bedrock (and/or paving of the reach of concern with concrete); vertical cutoff of the alluvium at the downstream end of the reach of concern; and reconstruction of the disturbed channel reach. Although a cost estimate of this alternative has not been developed, it is anticipated that it would in the tens to hundreds of thousands of dollars.

Alternative 7 - Plug St. Louis Tunnel Adit and All Other Openings. This alternative considered installing a watertight door on the St. Louis Tunnel, plugging all openings above the St. Louis level, and allowing the water table to rise to a level at or above the highest level of the known or inferred interconnected underground mine workings. Submergence of sulfides would prevent oxidation and the higher water table would tend to decrease surface water and groundwater inflows. It is apparent that the potential benefits from such an approach would have to be carefully weighed against some very significant accompanying potential risks. These risks include, among others: 1) reactivating currently dormant massive landslide deposits immediately north of the St. Louis Tunnel on the lower slopes of CHC Hill that are known to have been actively moving prior to the construction of the tunnel; and 2) creating new points/areas of uncontrolled seepage discharge (and possibly local blowout of near surface workings) that may require collection and treatment.

During the course of evaluating this alternative a different plugging concept was conceived. This concept envisions disposing of settled solids generated during treatment of tunnel discharge by lime addition into open underground workings where accessible in the interconnected Telescope – Dolores Mountain mines. Potential advantages of this approach are: increasing on-site solids storage capacity; reducing overall permeability of the underground workings "aquifer" and thus groundwater flows; and eliminating human and environmental contact with these wastes. Potential issues are similar to those noted above for plugging the mine workings surface openings relative to groundwater level/pressure build-up and development of uncontrolled new areas of seepage discharge. In addition, sufficiently large open areas of workings would have to be identified and the solids conveyed or pumped as a slurry to the disposal reaches at significant technical challenge and capital and O&M cost.

Further consideration of this alternative is not recommended given both the very high cost of the field investigations (deep well drilling and aquifer testing) and groundwater modeling that would be necessary to even attempt to estimate the response of the groundwater system to such changes, and the ultimate remaining uncertainty relative to the risks noted above.

2.5.2.3 Preferred Alternative

Based on the preliminary evaluation of alternatives discussed in Section 2.5.2.2, consideration of further pursuing the following alternatives (in order of priority) is recommended:

- *Alternative 4 – Reduction or Elimination of Oxygen Supply* (complete field reconnaissance of possible openings south of Silver Creek; complete conceptual design of air closures and estimate order of magnitude cost of implementation with and without air closure at the St. Louis Tunnel; if results and costs indicate, proceed with preliminary design and cost estimating of air closures)
- *Alternative 5 - Segregation of Water Descending from the Blaine Level through the No. 3 Shaft* (conduct flow measurement and water quality sampling and analysis at least three times – winter low flow in Silver Creek/Dolores River, shortly after peak of spring runoff, and during late summer/early fall; assumes that safe entry for investigations can be made without extensive stabilization of near surface portion of Blaine Tunnel; if results indicate, proceed with preliminary design and cost estimating of segregated treatment of Blaine flows)
- *Alternative 6 - Controlling Inflow of Surface Water* (evaluate potential merits of flow measurements and tracer dye testing relative to concept of sealing off inferred inflows to workings at the Silver Creek, Blackhawk Fault, Argentine-Blaine workings nexus; if results of field investigations are positive, proceed with preliminary design and cost estimating)

In each case, the additional investigations and evaluations noted in Section 2.5.2.2 (and briefly summarized in the list above) would first need to be conducted to provide a better basis for deciding whether to proceed to final design and implementation of any one or all of these measures.

2.5.3 Inflow from Argentine Seep

2.5.3.1 Issue/Objectives

Groundwater seepage currently discharges to Silver Creek at the downstream toe of the reclaimed Argentine Tailings. Measured rates of seepage discharge vary up to a typical higher value of about 40 gpm (with a few measurements in the 50-100 gpm range and an outlier at 287 gpm). The discharge is characterized by elevated concentrations of various metals including especially zinc. It is likely that an ongoing evaluation of Silver Creek by CDPHE/WQCD will identify this seepage as one of several sources of zinc loading confirming a 303(d) listing of the segment of Silver Creek below the Town of Rico diversion (COSJDO09) based on Zn and possibly other metals loads.

The objective of Atlantic Richfield Company at some point in the future considering proactive, voluntary treatment of this seepage discharge under TMDL regulation is to minimize the potential that the discharge is identified for remediation under CERCLA, and possibly as a basis to avoid it being considered as a point source requiring a CDPS permit with numeric discharge limits.

2.5.3.2 Alternatives Considered

Four alternatives have been identified and conceptually considered to address this issue. These include: pumping the discharge to the Blaine Tunnel for conveyance to the St. Louis Tunnel via the No. 3 Shaft; a pipeline to convey the flow by gravity to the St. Louis Ponds Treatment System; a drill hole to convey the flow directly to the St. Louis Tunnel at its closest approach; and a local passive treatment system. Each of these concepts is briefly discussed as follows.

Pumping to Blaine Tunnel No. 3 Shaft. This alternative envisions collection of seepage in a wet well at the seepage site, pumping the seepage up to the No. 3 Shaft in the Blaine Tunnel via a buried pipeline, dropping the flow (together with Blaine Tunnel flows) into the No. 3 Shaft which intersects the St. Louis Tunnel, and thereby ultimately conveying the flow to the St. Louis Ponds site for treatment. This would require approximately 3400 feet of 4-6 inch buried pipe rising approximately 160 feet in elevation and a pump rated to convey up to at least 100 gpm. Design would have to consider the need for full-time power (solar with battery back-up versus conventional overhead service), winter temperatures, potential encrustation due to mineral precipitation (and a means to clean the pipeline), and periodic inspection and maintenance. Advantages with this alternative are the consolidation of wastes by disposal in the No. 3 Shaft with like metals bearing water, and routing of the pipeline beneath at existing access road and across the reclaimed surface of the Argentine Tailings thereby minimizing new disturbances. The pipeline would also remain accessible for maintenance if needed.

Pipeline to St. Louis Ponds Treatment System. In this alternative a buried pipeline would be constructed along existing old mining roads from the seepage site to the St. Louis Ponds site. This would require a collection gallery at the seepage site to convey the flow by gravity into the pipe, approximately 7600 feet of 4-8 inch pipe dropping approximately 340 feet (for an average slope of about 0.045 ft/ft). Pipe size would be based on pipe maintenance. Means should be provided for pipe clean-out in the event that encrustation by precipitation occurs, and energy dissipation may be required depending on the type of pipe selected. Advantages of this alternative are that the system is downhill by gravity for the full length of the alignment, and the alignment can follow existing old mining roads and thereby minimize any significant new ground disturbance.

Drill Hole to St. Louis Tunnel. The closest straight line distance from the seepage site to the St. Louis Tunnel (and thereby to treatment at the St. Louis Ponds site) is approximately 2160 feet (2140 feet horizontal and 300 feet vertical for a slope from the horizontal of about 8 degrees or 14 percent). Under this alternative a boring would be drilled from the seepage site to the tunnel and cased if/as needed depending on rock conditions. This would require a specialized drill rig capable of directional drilling an 8-10 inch nominal OD hole (to case with 6-8 inch pipe) at a shallow angle. The control on the directional drilling would have to be very precise in order to intersect the approximately 8x12 foot tunnel bore from a distance of over 2000 feet. It is unknown at present if this degree of precision is attainable with current technology, especially at such a shallow drilling angle. The advantages of this alternative are that it requires the shortest conveyance of flows to the St. Louis Tunnel, no power is required, it avoids surface disturbance other than a small seepage collection gallery, and no operation is required. Provision would have to be considered for clean-out of encrustation as for the two previous alternatives. Pipe maintenance with this alternative could be more difficult than for the other conveyance alternatives considered..

Passive Treatment. Depending on the maximum flow rate requiring treatment and the criteria for discharge water quality, it may be feasible to design and construct an all-weather passive treatment system at or near the existing seepage site. Dr. William J. Vail of Allegheny Mineral Abatement, Inc. under subcontract to SEH tested the efficiency of his proprietary treatment process (based on producing project-specific microbes) on water sampled from the Argentine Seep (among other small sources in the watershed). Treatment efficiency for metals, including especially zinc, was found to be favorable even under cold weather conditions.

2.5.3.3 Preferred Alternative

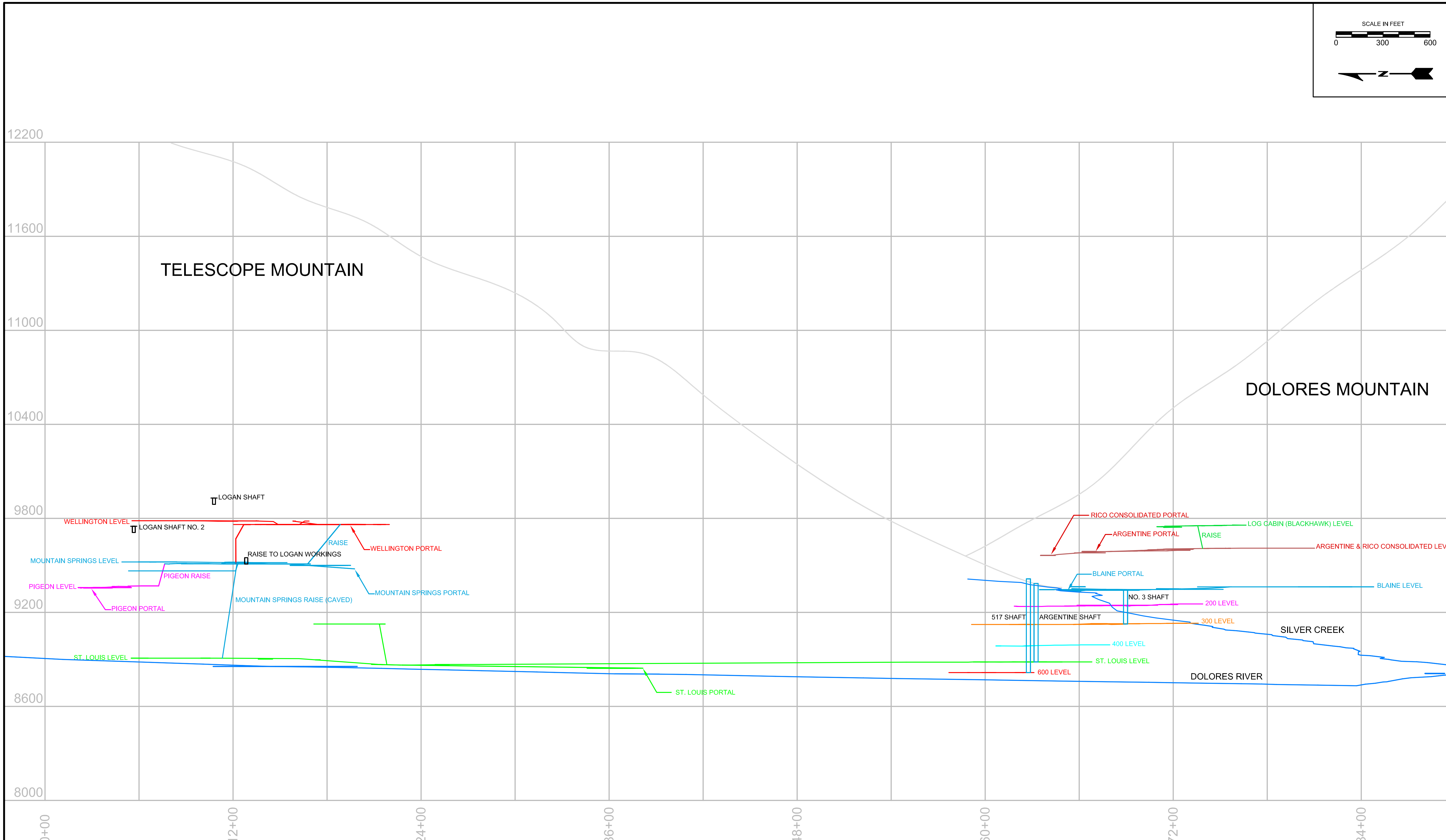
A preferred alternative has not been identified pending further evaluation of the alternatives described above. Key factors and criteria that will need to be considered in comparing alternatives include but are not necessarily limited to: discharge water quality criteria (improvement versus numeric limits); technical feasibility; power needs versus gravity operation; O&M requirements (including equipment replacement); and both capital and O&M cost.

~~2.5.4 Wetlands~~

~~2.5.4.1 Issue/Objectives~~

~~At least the southern portion of the St. Louis Ponds site is characterized by the presence of pond shoreline and shallow water wetlands. At least some portions of these habitats would classify as jurisdictional under a formal wetlands evaluation. If jurisdictional wetlands are to be disturbed by dredging or filling it will be necessary, at a minimum, to obtain a Section 404 permit (possibly a Nationwide permit if the area of disturbance is minimal).~~

~~Actions that might be found to impact jurisdictional wetlands under the preferred treatment and ponds system alternatives include the conversion of Pond 13 from its present condition to an enhanced drying/consolidation site for treatment solids and the possibility of putting Pond 10 into the active flow system to add additional polishing treatment. This assumes that these ponds exhibit sufficient wetland characteristics at least locally (seasonal saturation or inundation of the surface to near surface, hydric/anaerobic soils, and hydrophytic vegetation) to be classified as jurisdictional. The other areas of potential local disturbance of jurisdictional wetlands under the preferred plan would be at various of the existing ponds where embankment and/or hydraulic structure rehabilitation or replacement is required, including possibly Pond 5 if it~~



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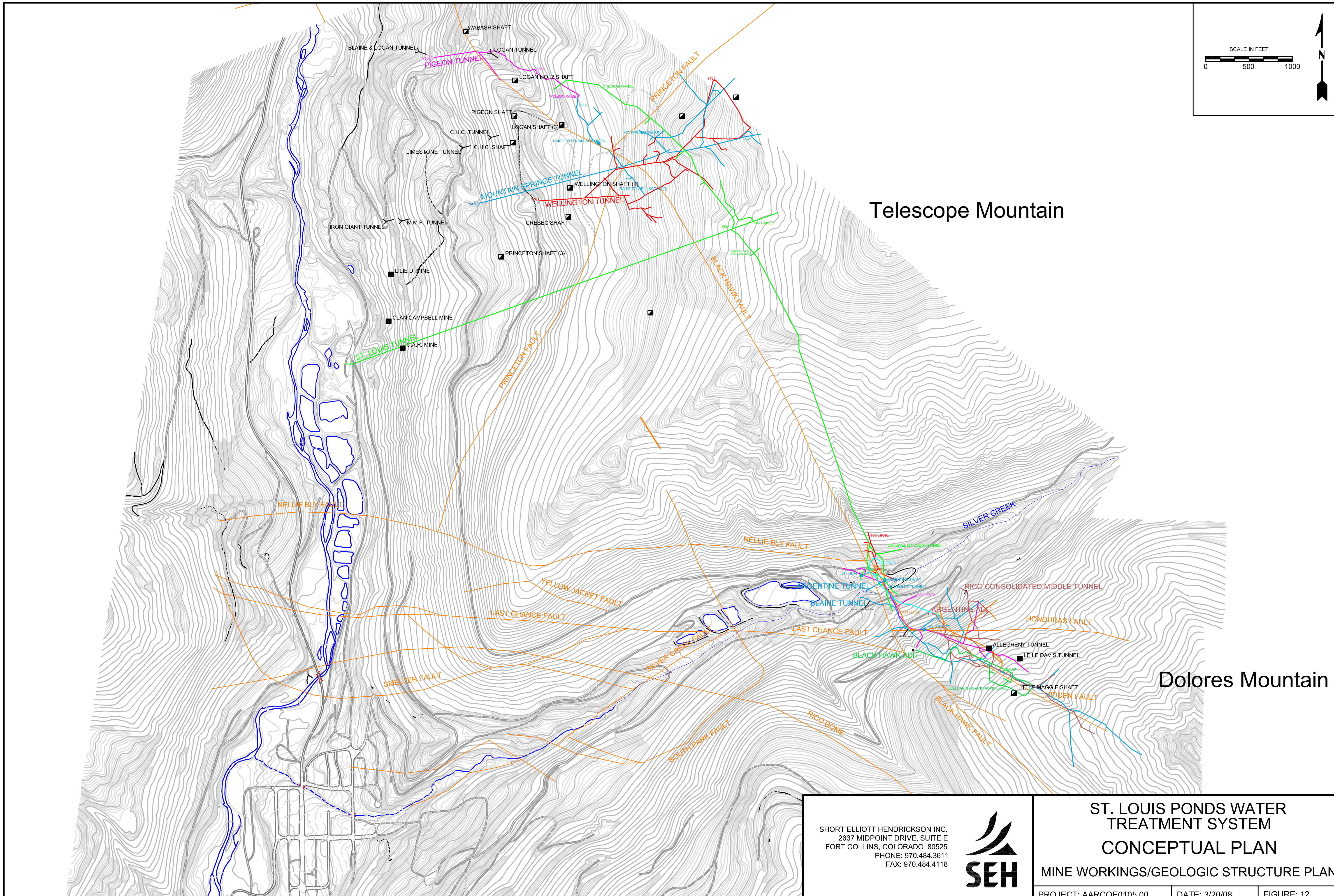
ST. LOUIS PONDS WATER TREATMENT SYSTEM

CONCEPTUAL PLAN

MINE WORKINGS PROFILE

PROJECT: AARCOE0105.00	DATE: 3/20/08	FIGURE: 13



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CONCEPTUAL PLAN

MINE WORKINGS/GEOLOGIC STRUCTURE PLAN

PROJECT: AARCOE0105.00 | DATE: 3/20/08 | FIGURE: 12

3-Mine Opening Reconnaissance Summary – Final

<u>Rico Field Reconnaissance Summary</u>

Reconnaissance performed August 3-4, 2006

1.0 Introduction

On August 3-4, 2006, a field reconnaissance was performed near the Town of Rico in order to identify potential surface openings to mine workings that may gravity drain to the St. Louis Tunnel. Most of the mine workings of interest are northeast of the Town of Rico, penetrating through the lower elevations of Telescope Mountain and Dolores Mountain. McKnight's (1974) report contains maps of the majority of relevant mine levels within the two mountains, compiled from several historical sources. These tunnels are displayed in plan view at their approximate locations within the two mountains on Figure 1, each level of tunnel being represented by a different color. The St. Louis Tunnel, shown in light green on Figure 1, discharges into the settling ponds north of Rico. Nearly all the workings displayed on the map are above the St. Louis level and have the potential to contribute to the St. Louis discharge.

As shown on Figure 1, there are two main groupings of mines. One is east of town on Silver Creek, just over a mile upstream from the confluence between Silver Creek and the Dolores River, and directly above the Argentine Tailings. These workings mainly penetrate Dolores Mountain and will be referred to as the Argentine Workings. The other grouping is further north within Telescope Mountain and will be referred to as the Telescope Workings. The two groupings are connected, however, by the long north-south St. Louis crosscut, which parallels the Blackhawk fault. As seen in Figure 1, many of the mine workings of interest run along this fault, which stretches northwest and southeast across the two mountains.

1.1 Argentine Workings Layout

A section view, showing each of the mine levels and their vertical relation to the St. Louis level is shown in Figure 2. There are eight known levels of mines on the Argentine side. On the north side of Silver Creek, there are six levels, the lowest of which is the 600 level and the highest is the 100 level. The 100 level is at about ground level at the intersection between the Blackhawk fault and Silver Creek. The St. Louis crosscut extends from the 500 level. On the south side of Silver Creek, there are at least five known levels of mines. Two of those levels are the 200 and 300 levels from the south side, which both pass underneath Silver Creek. The ground level tunnel, which is on approximately the same plane as the north side's 100 level, is known as the Blaine Tunnel. The upper two levels above the Blaine show no vertical connection to the Blaine; as such a connection could not be identified from historical maps. However, there is indication in some historical documents that the two levels do connect at some point. Thus, all levels from the Argentine side are assumed to drain to the bottom levels on the north side of Silver Creek, and, after filling the short 600 level, to flow down the St. Louis crosscut and out the St. Louis Tunnel.

1.2 Telescope Workings Layout

On the Telescope side, there were four levels of workings mapped by McKnight (1974) – the St. Louis, Pigeon, Mountain Springs and Wellington – that were connected at one time. In addition, historical documents make reference to the Logan tunnels, and two Logan shafts are displayed on historical maps. A map of these workings was not obtained and therefore not shown on Figure 1. Regardless, it is important to note the possibility that fairly extensive tunnel workings may have once existed between the Wellington and Mountain Springs levels. Besides these four main tunnels, several other tunnel entrances are displayed on historical maps, such as the Iron Giant, M.M.P., Limestone and C.H.C. Tunnels. However, there is no indication from any source that these tunnels penetrated far into the mountain and connected with the main workings associated with the St. Louis Tunnel.

1.3 Purpose and Method

As mentioned above, the purpose of the field reconnaissance was to identify openings that could potentially access any of these workings and thus affect the discharge of the St. Louis Tunnel. Several generations of historical maps gave approximate positions of former openings. These openings are identified on Figures 3 and 4. All of these locations, however, were digitized from paper maps and can be considered very approximate. Historical maps typically gave slightly different locations, and thus estimates were made in regards to their actual locations. During the reconnaissance, an effort was made to locate these openings and determine whether or not they could influence the St. Louis discharge. The coordinates of each point of interest that was located during reconnaissance were recorded and labeled with a number and 3-letter suffix according to its associated mine workings ("stl" for the Telescope workings directly above the St. Louis Tunnel, and "arg" for locations near the Argentine workings). Each of these points is also shown on Figures 3 and 4, and a corresponding description can be found in Table 1.

2.0 Telescope Mountain

As shown in Figure 1 and 3, there was at one time a road that wound up much of Telescope Mountain and provided access to the Pigeon, Mountain Springs and Wellington Tunnels. Nevertheless, the only topography available that shows most of the area of interest was constructed in 1980. The hope was that these tunnels and the nearby shafts would still be accessible by road, and in fact, the road did still provide reasonable access to each of these tunnels.

2.1 Pigeon Tunnel

The lowest of the three major tunnels above the St. Louis level is the Pigeon Tunnel, which was a short hike from the northern most sharp bend in the access road. North of the bend, there is a large opening and flat bench at the foot of what appears to be a waste rock pile, with large gray rocks littering the hillside. Upon climbing to the top of this hill, however, there was found another tier of waste rock, composed of smaller, rust-colored rocks. This pile is shown in the photo to the right. At the top of this pile is a slight depression into the side of the hill, indicating that a tunnel may have been present at one time. However, there is now very little remnant. Besides, the Pigeon Tunnel probably did not offer much drainage contribution to the St. Louis Tunnel. The Pigeon Raise, shown on Figure 2, rises from the Pigeon level about 150 feet to the highest point on the northern branch of the Mountain Springs workings. Therefore, it is unlikely that water would drain directly from the Mountain Springs to the Pigeon workings, and drainage from the Pigeon workings does not have a direct path to the St. Louis level. Coordinates of the likely tunnel location were not taken due to lack of satellite coverage. However, point 16stl was taken from the bench at the bottom of both piles.

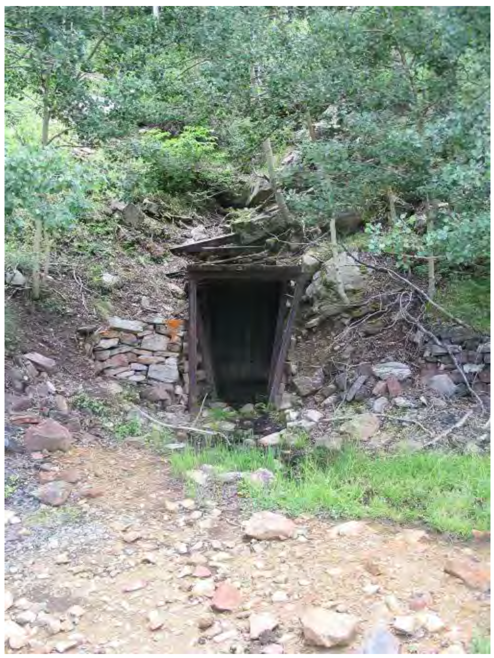
2.2 Mountain Springs Tunnel

The Mountain Springs Tunnel (15stl) is located immediately above the Pigeon workings, and is the tunnel showing the most extensive excavation. The tunnel's portal is at the top of several very large waste rock piles, the uppermost of which provides an open, flat bench for easy access. The portal location is slightly uphill of this bench in the more vegetated area. It was easily located, however, by following a small stream of water that was discharging from the former portal location. The tunnel itself has long been collapsed and shows very little indication of its prior existence besides the discharge. A photo of the collapsed tunnel is shown below. Its discharge runs several hundred yards downhill and to the north of the uppermost waste pile before pooling at the bank of the access road, where it appears to seep back into the ground. In addition to the stream originating at the former tunnel entrance, there is also an obvious drainage path that flows adjacent to the tunnel and its discharge. This path is the bright yellow color of the waste

rock, and, when traced uphill, appears to come from the waste rock pile below the Wellington Tunnel. The drainage path is pictured to the right.

The upper portion of the Mountain Springs workings, located furthest back into the mountain, may gravity drain to the St. Louis Tunnel via the now reportedly caved Mountain Springs Raise. Additionally, this raise continues up to the higher Wellington workings. Thus, the upper portion of the Wellington workings above the intersection with the raise may drain directly to the Mountain Springs level and then to the St. Louis level. The lower portion of the Mountain Springs workings, however, should drain to the tunnel entrance.

2.3 Wellington Tunnel



The highest major tunnel on Telescope Mountain is the Wellington Tunnel, whose portal is almost 300 feet higher than the Mountain Springs Tunnel, but directly uphill from it. (However, as previously mentioned, the Logan Tunnel workings also likely exist between the Mountain Springs and Wellington levels, although their extent and location could not be determined from available sources). The Wellington Tunnel is also at the top of a large waste pile with a flat bench on top. Unlike the Pigeon and Mountain Springs Tunnels, the Wellington Tunnel has not collapsed or been close and is thus still open and accessible. The entrance is gated, but there is no visible air blockage, and the framework of the tunnel entrance appears to be intact. There is a small discharge of water that exits the tunnel, although it ends in a small pool about 20 yards from the tunnel. As mentioned above, the lower portion of the Wellington workings should drain to the tunnel entrance, while much of the upper portion may drain to the Mountain Springs level and then to the St. Louis Tunnel. The tunnel is shown in the photo above.

2.4 Other Tunnels

Besides the three main tunnels discussed above, there appears to be other mine activity and waste rock piles just uphill from the Soil Lead Repository. Historical maps show at least three tunnels that once existed in this area: Lilie D., Clan Campbell and C.A.R Tunnels. Upon examining the top of these waste piles, there were found three locations (17stl, 18stl & 19stl) that may have at one time been these tunnel portals. Each is found on a small flat bench at the top of a waste pile, and each appears to be a slight depression into the hill. If

tunnels existed there at one time, they have long been collapsed and there is presently very little indication of former tunnel structure. As a result, there is little opportunity for water or air to enter or exit these locations. The photo to the right, likely the former location of the C.A.R. Tunnel, shows perhaps the most evidence remaining that it may have once been a tunnel. Nevertheless, there is no indication of links between these tunnels and the rest of the workings. Perhaps they were short exploratory tunnels that never penetrated to the other mines.

2.5 Telescope Shafts

One of the main purposes of the reconnaissance was to locate former shafts on the mountain and determine whether or not they could still offer access to the mines for either air or water. As shown on Figure 3, there were eight named shafts and three unnamed shafts shown on historical maps that potentially accessed the workings. During the field reconnaissance, ten locations were found that appeared to be former shaft openings. Up to six of these correspond relatively closely with six of the mapped shafts. The other four were other likely shafts that were not shown on available historical maps. At least three of the shafts displayed on historical maps – the Pigeon Shaft, Logan Shaft

and C.H.C. Shaft – did not appear to be in position to access any of the mapped workings. However, they may be in position to access the previously mentioned

Logan workings. Every shaft found in the field appeared to have been covered long ago, with no current access to the mine workings. The only indication that a shaft may have been there at one time was a bowl shaped depression in the ground, as shown in the above photo. These former shafts do not appear to be an avenue for either water or air to enter the mine.

3.0 Argentine Workings

The 1980 topography also shows a road that winds up much of the lower elevations of Dolores Mountain, giving access to several of the tunnels around the Argentine workings. There appeared to be at least five tunnels that were accessible, although historical documents indicated the one time presence of others. There were also several shafts in the area that presented potential openings to the workings. In the area around the intersection of Silver Creek and the Blackhawk fault, at the top of the Argentine Tailings, there are several still-standing structures and assorted debris that give testimony to the extensive operations that were once active in this area.

3.1 Blaine and Argentine Tunnels

On ground level (100 level or Blaine level) at the top of the Argentine Tailings are two tunnel portals, the Argentine I (there is another portal further up Dolores Mountain that is also called the Argentine Adit/Tunnel; this will be referred to as Argentine II) and the Blaine Tunnel. The Argentine I Tunnel (2arg) opens on the north side of Silver Creek while the Blaine Tunnel (3arg) opens on the south. The two portals are separated by only about 50 yards and a bridge over Silver Creek. The two pictures to the right show the tunnels and their relation to one another. The pictures were taken looking east, up Silver Creek, with the Argentine I portal above and the Blaine below. Each tunnel is still open and appears to presently offer access to the mines. While there is little opportunity for runoff to flow into the mines from these locations, there is, of course, exposure the outside atmosphere.

3.2 North of Silver Creek

As shown on Figure 2, there are six below-ground levels on the north side of Silver Creek, accessed primarily by the Argentine I Tunnel. Historical maps indicate that there are two shafts that also access these levels – the 517 Shaft and the Argentine Shaft – whose locations are shown on Figures 2 and 4. The locations of these shafts were presumed to be found during field reconnaissance (5arg and 6arg); each marked by what appears to be a curved ventilation pipe. The 1980 Rico Hazard Elimination report shows schematics of several shaft covering alternatives, one of which is presented in Figure 5. The shafts appear to have been covered by this process and vented with the indicated pipe. Pictures of each of these locations are shown below. The larger diameter pipe on top presumably marks the Argentine Shaft, while the smaller diameter pipe most likely vents the 517 Shaft.

Also on the north side of Silver Creek is what may be another opening to the Argentine mine workings. The opening is housed by a tall, corrugated metal structure, and penetrates horizontally into the hill (1arg). There is a conveyor belt stretching into the hole, which exits and continues through a horizontal shaft to the top of another adjacent building located downslope. This opening is located uphill and slightly west of the Argentine and Blaine tunnels, although it is not marked on any known maps and may not access the mines at all. Nevertheless, it is worth noting for future closure possibility. Photos of the openings and its housing are shown above and to the right.

3.2 South of Silver Creek

The more extensive levels of the Argentine workings are to the south of Silver Creek, penetrating into Dolores Mountain. As shown in Figures 1 and 4, there was at one time a road that wound up part of the mountain to access the Rico Consolidated, Argentine and Blackhawk Tunnels. This road was followed for a short distance but soon proved inaccessible. A large, steep, V-shaped channel of waste rock has been formed that cuts directly down the slope of the mountain, blocking the lower and upper section of the road. Nevertheless, the road still provided good access by foot on the other side of this

c
tures of this channel are shown to the right.
The above left photo was taken where the channel intersects the lower section of road (10arg) and looks downslope toward Silver Creek. The photo on the right was taken from the upper section of road (8arg) and is looking up toward the Blackhawk Tunnel. The topography in Figures 1 & 4 shows a narrow, but steep drainage at its approximate location.

3.3 Rico Consolidated Middle Tunnel

The lowest accessible tunnel is the Rico Consolidated Middle Tunnel (the lower and upper consolidated tunnels also once existed, but their locations were not apparent from historical records). Just above the sharp, eastern most bend in the road, there is a sizeable waste rock pile, which continues down to the lower section of road. The top of the pile was not accessed due to weather conditions, but its waste pile was noted and photographed from location 11arg. The photo to the right shows the view from the bottom of this pile. Further reconnaissance could determine the state of the tunnel at the top of this pile.

3.4 Argentine II Tunnel

The Argentine II Tunnel is located just up the road from the Rico Consolidated Middle Tunnel at the top of a large bench of waste rock (9arg). The tunnel has an unlocked gate, which was slightly open. There did not appear to be anything blocking tunnel access, leaving it open to air contact, although there were not immediate signs of water discharge from the tunnel. The photo below shows the tunnel entrance.

3.5 Blackhawk Tunnel

Further up the mountain slope is the Blackhawk Tunnel (7arg), also at the top of a large waste rock pile. Although similar to the other tunnels, it appears to be sealed by an air door, preventing access to the mine. Immediately to the east of the tunnel's waste pile is the rock channel mentioned previously. Yet the channel continues upslope through other waste material. It appears that a significant amount of waste was also removed from some location further up the mountain, although access to this location looked to be quite difficult. According to historical maps, the Leile Davis and Allegheny Tunnels, and the Little Maggie shaft is located some ways up the slope, and may have been the point from which this other material was removed. The photos above and to the right show the tunnel itself and the waste immediately above the tunnel.

4.0 Conclusions

From observations made during the field reconnaissance, it may be concluded that there is very little opportunity for direct surface runoff to enter the mines. There were no shafts found that still offer a means of entry. Each has been covered and gives only a slight depression in the ground surface as an indication that a shaft may once have been present. All observed tunnels are situated in such a way that runoff would not drain to them. Several of the tunnels, however, do appear to allow for air access, giving some opportunity for undesired chemical processes. Nevertheless, water does not likely enter the mines as direct surface runoff, but instead may seep through the ground into the mines or enter via transport by the Blackhawk fault.

4-St. Louis Underworkings – Historic Information Summary

Underworkings in St. Louis Tunnel Area (sorted by Elevation)

Name Given	Likely Name	Type of Feature	Easting	Northing	Elevation	Comments	Source			
Uncle Ned		Mine	2272911	1389268	10925		EMC2 (2002)		35	3
Unnamed	Uncle Ned	Tunnels (2)	2273052	1389217	10855		USGS Rico Folio (1905)		35	3
Uncle Ned		Mine	2272953	1389072	10825		McKnight Geologic Map (1974)		35	3
Little Maggie Shaft		Shaft	2275903	1385109	10790		EMC2 (2002)		55	2
Unnamed	Little Maggie	Shaft	2275810	1385243	10735		USGS Rico Folio (1905)		55	2
Unnamed		Adit	2273095	1390831	10788		McKnight Geologic Map (1974)		20	1
Worlds Fair		Mine	2273145	1388976	10770		EMC2 (2002)		37	3
Unnamed	Worlds Fair	Tunnels (2)	2273190	1389000	10675		USGS Rico Folio (1905)		37	3
Worlds Fair		Mine	2273382	1388753	10630		McKnight Geologic Map (1974)		37	3
Unnamed		Shaft?	2271621	1389561	10628		McKnight Geologic Map (1974)		31	1
Unnamed		Tunnel	2272554	1391274	10610		USGS Rico Folio (1905)		17	1
Unnamed	Leile Davis	Tunnel	2275853	1385596	10500		USGS Rico Folio (1905)		50	2
Leile Davis		Mine	2275942	1385545	10490		EMC2 (2002)		50	2
Unnamed		Adit	2271914	1389686	10350		McKnight Geologic Map (1974)		30	1
Unnamed		Adit	2271795	1389693	10310		McKnight Geologic Map (1974)		29	1
Allegheny		Mine	2275578	1385688	10280		EMC2 (2002)		49	2
Unnamed	Allegheny	Tunnel	2275492	1385691	10240		USGS Rico Folio (1905)		49	2
Unnamed		Shaft	2275545	1383784	10260		USGS Rico Folio (1905)		60	1
Unnamed		Tunnel	2273865	1383886	10250		USGS Rico Folio (1905)		59	1
Unnamed	Wildcat	Tunnel	2275484	1384385	10240		USGS Rico Folio (1905)		57	2
Wild Cat		Adit	2275146	1384338	10200		McKnight Geologic Map (1974)		57	2
Unnamed		Adit	2275383	1385487	10226		McKnight Geologic Map (1974)		54	1
Unnamed		Tunnel	2273887	1384090	10125		USGS Rico Folio (1905)		58	1
Unnamed		Shaft	2271986	1391829	10000		USGS Rico Folio (1905)		11	1
Unnamed		Adit	2274943	1385511	10000		McKnight Geologic Map (1974)		53	1
Crebec Shaft		Shaft	2270759	1390678	9995		EMC2 (2002)		21	2
Unnamed	Crebec	Shaft	2270674	1390666	9900		USGS Rico Folio (1905)		21	2
Wellington Shaft		Shaft	2270674	1391014	9970		EMC2 (2002)		18	5
Unnamed	Wellington	Shaft	2270693	1391003	9950		USGS Rico Folio (1905)		18	5
Wellington Mine		Mine	2270225	1390904	9760	Demolition & Cleanup	Hazard Elimination Bid Invitation (1980)	115	18	5
Wellington Tunnel		Tunnel	2270336	1390834	9760	Sealed with block wall and steel door	Hazard Elimination Bid Invitation (1980)	116	18	5
Wellington		Mine	2270321	1390819	9710		McKnight Geologic Map (1974)		18	5
Unnamed	Logan	Shaft	2270636	1391789	9950		USGS Rico Folio (1905)		14	4
Logan Shaft		Shaft	2270599	1391732	9930		EMC2 (2002)		14	4
Logan Shaft		Shaft	2270560	1391626	9900	Closed by optional technique	Hazard Elimination Bid Invitation (1980)	117	14	4
Logan Shaft		Shaft	2270672	1391721	9890		McKnight Geologic Map (1974)		14	4
Black Hawk		Mine	2275011	1385736	9940		EMC2 (2002)		48	3
Unnamed	Black Hawk	Tunnel	2274923	1385744	9890		USGS Rico Folio (1905)		48	3
Black Hawk		Adit	2274678	1385712	9760	Sealed with block wall and steel door	Hazard Elimination Bid Invitation (1980)	161	48	3
Unnamed		Adit	2274848	1385554	9925		McKnight Geologic Map (1974)		52	1
Pigeon Shaft		Shaft	2270026	1391866	9865		EMC2 (2002)		13	2
Unnamed	Pigeon	Shaft	2270049	1391830	9825		USGS Rico Folio (1905)		13	2
C.H.C. Shaft		Shaft	2270109	1391534	9865		EMC2 (2002)		15	4
Unnamed	C.H.C	Shaft	2269973	1391550	9775		USGS Rico Folio (1905)		15	4
C.H.C. Tunnel		Tunnel	2269805	1391576	9700		USGS Rico Folio (1905)		15	4
C.H.C. Tunnel		Tunnel	2269740	1391595	9670		EMC2 (2002)		15	4
Logan No. 2 Shaft		Shaft	2270048	1392236	9815		EMC2 (2002)		9	2
Logan No. 2 Shaft		Shaft	2270059	1392250	9750		USGS Rico Folio (1905)		9	2
Unnamed		Shaft	2272610	1392047	9810		USGS Rico Folio (1905)		10	1
Unnamed		Tunnel	2274110	1384862	9800		USGS Rico Folio (1905)		56	1
Collapsed Black George Adit		Adit	2270411	1389538	9760	Closed by optional technique	Hazard Elimination Bid Invitation (1980)	114	32	2
Unnamed	Black George Adit	Adit	2270442	1389553	9732		McKnight Geologic Map (1974)		32	2
Unnamed		Adit	2275863	1386533	9750		McKnight Geologic Map (1974)		45	1
Unnamed		Adit	2274609	1385643	9750		McKnight Geologic Map (1974)		51	1
Rico Consolidated		Mine	2275433	1386350	9730		EMC2 (2002)		47	2
Rico Consolidated		Adit	2275106	1386354	9575		McKnight Geologic Map (1974)		47	2
Logan Tunnel		Tunnel	2269813	1392507	9700		EMC2 (2002)		7	3
Logan Tunnel		Tunnel	2269843	1392523	9650		USGS Rico Folio (1905)		7	3
Logan Tunnel		Tunnel Entrance	2269591	1392671	9550		McKnight Geologic Map (1974)		7	3

Underworkings in St. Louis Tunnel Area (sorted by Elevation)

Name Given	Likely Name	Type of Feature	Easting	Northing	Elevation	Comments	Source			
Princeton		Mine	2270076	1390638	9670		EMC2 (2002)		22	2
Princeton		Tunnel	2270013	1390624	9625		USGS Rico Folio (1905)		22	2
Unnamed		Adit	2275826	1386675	9650		McKnight Geologic Map (1974)		44	1
Argentine Adit w/ Concrete Portal		Adit	2274937	1386157	9640		Hazard Elimination Bid Invitation (1980)	163	41	5
Argentine Group		Mine	2274442	1386621	9470		EMC2 (2002)		41	5
Argentine		Shaft	2274414	1386648	9380		USGS Rico Folio (1905)		41	5
Argentine Haulage Adit		Adit	2274129	1386391	9360	Closed by optional technique	Hazard Elimination Bid Invitation (1980)	94	41	5
Argentine Tunnel		Tunnel	2273956	1386322	9360	Sealed with block wall and steel door	Hazard Elimination Bid Invitation (1980)	95	41	5
Unnamed		Adit	2270070	1393923	9623		McKnight Geologic Map (1974)		2	1
Unnamed		Adit	2270258	1389924	9570		McKnight Geologic Map (1974)		28	1
Princeton Shaft		Shaft	2269902	1390208	9550	Closed by optional technique	Hazard Elimination Bid Invitation (1980)	113	25	2
Unnamed	Princeton Shaft	Shaft	2269948	1390282	9530		McKnight Geologic Map (1974)		25	2
Unnamed		Adit	2269623	1393930	9540		McKnight Geologic Map (1974)		1	1
Limestone Tunnel		Tunnel	2269465	1391458	9500		USGS Rico Folio (1905)		16	3
Unnamed	Limestone	Adit	2269640	1391305	9445		McKnight Geologic Map (1974)		16	3
Limestone Tunnel		Tunnel	2269416	1391494	9440		EMC2 (2002)		16	3
Pigeon		Tunnels (3)	2269392	1392682	9490-9520		USGS Rico Folio (1905)		6	3
Pigeon		Mine	2269202	1392577	9400		EMC2 (2002)		6	3
Pigeon		Mine	2269130	1392552	9205		McKnight Geologic Map (1974)		6	3
Wabash		Mine	2269492	1392809	9485		McKnight Geologic Map (1974)		4	3
Wabash		Shaft	2269340	1392831	9475		USGS Rico Folio (1905)		4	3
Wabash		Mine	2269218	1392867	9430		EMC2 (2002)		4	3
Mountain Springs Tunnel		Tunnel	2269467	1390934	9480		USGS Rico Folio (1905)		19	5
Mountain Springs Tunnel		Tunnel	2269367	1390955	9470		EMC2 (2002)		19	5
Mountain Springs		Adit	2269658	1390836	9443		McKnight Geologic Map (1974)		19	5
Mountain Springs		Mine	2269490	1390734	9443		McKnight Geologic Map (1974)		19	5
Mountain Springs Tunnel		Tunnel	2269542	1390808	9440	Closed by optional technique	Hazard Elimination Bid Invitation (1980)	107	19	5
Unnamed		Adit	2275486	1386902	9470		McKnight Geologic Map (1974)		40	1
Blaine		Mine	2274029	1386484	9455		EMC2 (2002)		46	2
Blaine Tunnel w/ Drainage		Tunnel	2274087	1386309	9360	Sealed with block wall and steel door	Hazard Elimination Bid Invitation (1980)	93	46	2
Last Chance Lode Adit		Adit	2274884	1386618	9440	Closed by optional technique	Hazard Elimination Bid Invitation (1980)	174	42	1
Silver Creek Mill Powder House		Structure	2273621	1386412	9400	Demolition & Cleanup	Hazard Elimination Bid Invitation (1980)	73	43	1
Blaine & Logan Tunnel		Tunnel	2268915	1392578	9310		EMC2 (2002)		5	3
Blaine & Logan Tunnel		Tunnel	2268980	1392589	9300		USGS Rico Folio (1905)		5	3
Unnamed	Blaine & Logan Tunnel	Adit	2268571	1392807	9153		McKnight Geologic Map (1974)		5	3
M.M.P.		Tunnel	2268781	1390620	9280		USGS Rico Folio (1905)		23	2
M.M.P.		Mine	2268744	1390646	9260		EMC2 (2002)		23	2
Iron Giant		Tunnel	2268579	1390608	9240		USGS Rico Folio (1905)		24	3
Iron Giant		Mine	2268560	1390634	9140		EMC2 (2002)		24	3
Unnamed	M.M.P. or Iron Giant	Adit	2268648	1390547	9120		McKnight Geologic Map (1974)		24	3
Unnamed		Adit	2268754	1391871	9201		McKnight Geologic Map (1974)		12	1
Collapsed Shed & Ore Bin	Lily D	Structure	2268782	1389869	9180	Demolition & Cleanup	Hazard Elimination Bid Invitation (1980)	100	27	3
Lily D		Mine	2268780	1389889	9150		McKnight Geologic Map (1974)		27	3
Lilie D		Mine	2268581	1390046	9130		EMC2 (2002)		27	3
C.A.R.		Mine	2268762	1389152	9160		EMC2 (2002)		36	1
Unnamed		Adit	2268794	1388292	9130		McKnight Geologic Map (1974)		38	1
Clan Campbell		Mine	2268791	1389306	9118		McKnight Geologic Map (1974)		33	2
Clan Campbell		Mine	2268601	1389467	9040		EMC2 (2002)		33	2
Unnamed		Adit	2268764	1387535	9085		McKnight Geologic Map (1974)		39	1
Governor		Mine	2267945	1393192	9040		EMC2 (2002)		3	1
Unnamed		Adit	2268220	1392319	8990		McKnight Geologic Map (1974)		8	1
Logan Tunnel		Tunnel	2267967	1390094	8910		EMC2 (2002)		26	2
Logan Tunnel (?)		Tunnel	2268029	1390074	8880		USGS Rico Folio (1905)		26	2
St. Louis Tunnel		Tunnel	2268233	1389297	8910		EMC2 (2002)		34	1

Surface Shafts

Shaft	Drainage Area	Closure Technique Likely Peformed	Connected to Workings?	Comments
Wabash	30		Perhaps	May likely be connected to Logan workings, which are connected to Mountain Springs workings. Also, shaft is located just to the east of Blackhawk Fault.
Logan No.2	14		Most likely	Logan workings are connected to Mountain Springs workings via raise
Unnamed	14.6		Perhaps	Shaft located near upper Wellington workings, approximately 200 feet above
Unnamed	15.7		Perhaps	Shaft located near upper Wellington workings, approximately 200 feet above
Pigeon	2.6		Perhaps	Pigeon workings eventually drain to St. Louis, but the given location of this shaft is several hundred feet from the mapped Pigeon workings; Its location, however, does appear to be above the assumed location of the Logan workings.
Logan	6.5	Optional closure technique	Most likely	Logan workings are connected to Mountain Springs workings via raise
C.H.C.	40.6		Perhaps	Location is most likely above Logan workings
Wellington	16.9	Sealed w/ block wall & steel door	Most likely	Probably drains to Wellington Tunnel, near its portal, but would have to backup a considerable distance (>1000') to access raises that would drain to the St. Louis level
Crebec	31.8		Perhaps	Most likely accesses Princeton Tunnel workings, which are at an elevation between the Wellington and Mountain Springs level, but of which we have no mapping
Princeton	40	Optional closure technique	Perhaps	See above
Unnamed	30.7		Unlikely	Does not appear to connect; may access Lilly D and Clan Campbell workings
Argentine	40.3		Yes	Drains directly to St. Louis level
Little Maggie	4.1		Perhaps	Appears to be access Log Cabin (Blackhawk) workings; we have not determined if these workings, along with the Argentine Tunnel workings, connect to the others
Unnamed	360.4		Unlikely	Does not appear to connect

Uncertainties

Argentine Workings	The Argentine Tunnel, Rico Consolodated Tunnel, and Log Cabin (Blackhawk) Tunnel are directly above the Blaine workings (by approximately 250'), and may drain there, but there is not an obvious connection
Logan Workings	The Logan workings are in the vicinity of the Mountain Springs and Pigeon workings, and there was once a raise from the Mountain Springs workings to the Logan workings, but we do not have reliable mapping or elevations for them.
Other Tunnels	Several tunnel portals were mapped in 1905, including the C.H.C., Limestone, Iron Giant, M.M.P. and Princeton, but we do not have any mapping of them. However, they are all in the vicinity of the Mountain Springs Tunnel.
Lilly D & Clan Campbell	These tunnels pass over the lower section of the St. Louis Tunnel, about 250' higher in elevation, but it does not appear that they are connected.
Last Chance Lode Adit	This adit may lead to some workings between the Blaine and Argentine levels, but we do not have any such mapping.

Fault Lengths (shown on DeLorme map)			
Fault	**Feet**	**Miles**	
Blackhawk	16,843	3.19	
Princeton East	2,703	0.51	
Princeton West	3,143	0.60	
Nellie Bly	3,333	0.63	
Honduras	2,736	0.52	
Last Chance	4,588	0.87	
Hidden	2,462	0.47	
Total	35,808	6.78	

5-Rico Mine Recon – August 6 – Table 1

Table 1
Mine Location Reconaissance - August 2006

GPS Point	Latitude				Longitude				Photos	Likely Name	Type	Likely Open to Air?	Description	1980 Haz Elim#
	Deg	Min	Sec	Dec. Deg.	Deg	Min	Sec	Dec. Deg.						
1arg	37	42	3.11745	37.70087	108	0	37.6807	108.01047	71-74		Conveyor	Yes	Just uplsople of Argentine Tailings; possibly horizontal adit into slope; conveyor belt exits from tunnel, continues up duct to feed downslope structure; covered by tall metal structure; opening ~3'x5'	
2arg	37	42	3.07305	37.70085	108	0	35.1483	108.00976	75-76	Argentine Tunnel	Tunnel	Yes	Tunnel on north side of Silver Creek; approx. 50' from bank	95
3arg	37	42	2.79306	37.70078	108	0	34.6339	108.00962	77-78	Blaine Tunnel	Tunnel	Yes	Tunnel on south side of Silver Creek; approx. 30' from bank	93
4arg	37	42	0.70471	37.7002	108	0	38.3106	108.01064	None		Bridge	N/A	Bridge crossing Silver Creek	
5arg	37	42	4.67079	37.7013	108	0	31.2501	108.00868	79-81		Ventilation Pipe	Yes	Large 3'-4' diameter ventilation pipe; on bench at top of waste rock pile; discolored rock at foot of pipe; potential shaft covering?	164?
6arg	37	42	4.32464	37.7012	108	0	35.6249	108.0099	82-83		Ventilation Pipe	Yes	~8" diameter ventilation pipe; on top of small waste rock pile	
7arg	37	41	56.771	37.6991	108	0	27.0029	108.0075	130-135	Log Cabin Tunnel or Black Hawk	Tunnel	No	Tunnel close with air door; top of large waste pile	161?
8arg	37	41	59.0773	37.69974	108	0	28.1178	108.00781	136-137		Road Intersection	N/A	Top intersection of road and "channel" of waste rock; channel is v-shaped, steep, ~10' wide at tope; flows straight down through waste piles	
9arg	37	42	1.03815	37.70029	108	0	24.8156	108.00689	138-141	Argentine Adit	Tunnel	Yes	Tunnel at top of pile; gated, but gate is open; appears to be accessible inside	163
10arg	37	42	2.63226	37.70073	108	0	30.1994	108.00839	145-146		Road Intersection	N/A	On waste rock channel at lowest intersection with road	
11arg*	37	42	3.72	37.70103	108	0	21.2	108.00589	142	Rico Consolidated Middle Tunnel	Toe of Pile	No	Photo taken looking up at pile, just on uphill side of first bend in the road	
12arg*	37	42	4.45	37.70124	108	0	23.7	108.00658	143	Rico Consolidated Middle Tunnel	Toe of Pile	No	Photo taken looking up at pile, ~50 yards downhill from first bend	
13arg*	37	42	3.33	37.70093	108	0	26.6	108.00739	144	Silver Creek	Creek	No	Looking downhill at Silver Creek, slightly downhill from 12arg; creek pools before flowing at outlet	
1stl	37	42	47.0931	37.71308	108	1	22.2243	108.02284	84-86	Wellington Tunnel	Tunnel	Yes	Gated off at entrance, yet still appears open to air; on large bench at top of large waste pile; small stream exiting & ending in large puddle 20yds from entrance	115,116
2stl	37	42	52.4771	37.71458	108	1	17.6658	108.02157	87-88		Shaft	No	Depression in ground: 10-15' deep, 15-20' wide	
3stl	37	42	52.8333	37.71468	108	1	17.2246	108.02145	None		Road Intersection	N/A	Intersection of road and trail just above Wellington shaft; trail not marked on map	
4stl	37	42	46.2941	37.71286	108	1	16.2693	108.02119	89	Crebec Shaft	Building	N/A	Large, recently built, circular building; raised on deck	
5stl	37	42	48.8736	37.71358	108	1	17.0804	108.02141	None		Road Intersection	N/A	Intersection of main road that continues up to building (4stl) and steeper road that climbs upslope to 10stl-14stl	
6stl	37	42	55.9726	37.71555	108	1	18.8157	108.02189	90-91	Logan Shaft	Shaft	No	Large rectangular depression: ~15' x 30'; Top of large waste pile	117
7stl	37	42	54.9301	37.71526	108	1	20.8649	108.02246	92	Pigeon Shaft	Shaft	No	Small waste pile; at top of pile are several small depressions, although one is more prominent	

Table 1
Mine Location Reconaissance - August 2006

GPS Point	Latitude				Longitude				Photos	Likely Name	Type	Likely Open to Air?	Description	1980 Haz Elim#
	Deg	Min	Sec	Dec. Deg.	Deg	Min	Sec	Dec. Deg.						
8stl	37	42	54.7688	37.71521	108	1	25.203	108.02367	93-94	CHC Shaft	Shaft	No	Depression on flat bench by side of road; large gray rocks scattered around; slight clearing of trees; GPS point taken on road, ~ 40' west of center of depressoin	
9stl	37	42	41.3995	37.7115	108	1	10.7543	108.01965	95		Shaft	No	Small depression: ~7' diameter, 3-4' deep; ~2000' S/SE of building (4stl); trail peters off shortly after depression	
10stl*	37	42	56.5	37.71569	108	1	4.1	108.01781	96		Shaft	No	Depression: ~6-8' deep, 8' diameter; no signs of waste	
11stl*	37	42	57.4	37.71594	108	1	9.5	108.01931	97		Shaft	No	Depression: ~3-4' deep, 6' diameter; no signs of waste	
12stl*	37	42	52.1	37.71447	108	1	10.2	108.0195	98-101		Shaft	No	Bench & slight depression at top of wate rock pile (large gray rocks); path splits bench	
13stl*	37	42	52.1	37.71447	108	1	14.1	108.02058	102-103		Shaft	No	Depression: ~3' deep, 8' wide; small hole at bottom, could drain some	
14stl*	37	42	49.3	37.71369	108	1	16.3	108.02119	104	Wellington Shaft	Shaft	No	Depression: ~3' deep, 10' wide; near fork of main road and upper road (5stl)	
									105-108		Drainage	N/A	Yellow drainage path; coming from what appears to be the Wellington waste pile; flows to the west of Mt. Springs Tunnel	
15stl	37	42	46.1823	37.71283	108	1	31.4073	108.02539	109-114	Mt. Springs Tunnel	Tunnel	No	Tunnel on top of very large waste pile; tunnel is collapsed/covered, with very little indication of formerly being a tunnel; steady stream flowing seaping through and flowing from tunnel location; water pools slightly downhill before continuing; appeasr to end and pool at road embankment	99-110
16stl*	37	43	2.58	37.71738	108	1	37.1	108.02697	115-119	Pigeon Tunnel	Tunnel	No	2 "tiers" of waste piles; lower pile: gray, large rock - toes at large open bench; higher pile: smaller, orange waste rock; at top of upper pile is a slight depression in the face of the mountain; tunnel assumed to be there but not obvious	
17stl	37	42	31.0957	37.70864	108	1	41.0181	108.02806	120-122, 129		Tunnel	No	Appears to be collapsed tunnel, though not obvious; directly upslope of repository; at tope of large waste pile; no signs of drainage from tunnel	
18stl	37	42	37.3633	37.71038	108	1	42.0351	108.02834	123-125		Tunnel	No	Appears to be collapsed tunnel; on slope just north of 17stl; several step of waste piles below	
19stl	37	42	36.0147	37.71	108	1	42.3917	108.02844	126-128		Tunnel	No	Appears to be collapsed tunnel, although it is slightly downhill and south of 18stl - could be waste from it; on wide bench at top of pile	

* Point not taken or unable to establish satellite coverage; Latitude/Longitude estimated

6-RICOSITE – Hazards Elimination Program

RICO SITE
HAZARDS ELIMINATION PROGRAM

			Site Rehabilitation		Demolition	Optional Closure Techniques		Mandatory Closure Techniques		Special Hazard Elimination Techniques	
			Topsoil Application	Fertilize, Seed & Mulch	Remove & Dispose	Concrete Cap	Doze & Seal	Bulkhead W/Drain	Sealed Bulkhead	See Key for Details	Perimeter Fencing
1	9	Beneficiation Plant			X						
2	11	Storage Shed			X						
3	13	Akeaha Tunnel					X				
4	14	Akeaha Mine Ore Bin			X						
5	20	Roy's Tract Mill Site								X	
6	21	Tram Tower & Ore Bin			X						
7	22	Area Access Roads			X						
8	23	Railroad Water Tower								X	
9	26	Santa Cruz Incline							X	X	
10	27	Silver Swan Adit Portal			X		X				
11	28	Atlantic Cable Shaft								X	
12	36	Prospect Pit									X
13	37	Partially Collapsed Shaft				X					
14	38	Prospect Pit									X
15	39	Union Carbonate Shaft w/Air Vent				X					
16	40	Union Carbonate Ore Bin & Aerial Tram								X	
17	41	Revenue Mine Site			X						
18	42	Pro-Patria Mine Building			X						
19	43	Pro-Patria Mine Storage Shed			X						
20	45	Pro-Patria Mine Powder House			X						
21	46	Pro-Patria Mine Ore Bin & Tram Bldg. w/ Loading Pump			X						
22	47	Skeptical Shaft		X			X				
23	48	Pro-Patria Aerial Tram Tower		X	X						
24	49	Partially Collapsed Shaft		X			X				
25	50	Ysabel Lode Prospect Pit									X
26	51	Ysabel Lode Prospect Pit		X			X				
27	52	Elliot Lode Prospect Pit		X			X				
28	53	Elliot Lode Prospect Pit		X			X				
29	54	Powder House		X	X						
30	55	Job Copper Lode Prospect Pit									X
31	56	Nora Lilly Mine Site			X						
32	57	Pro-Patria Tram Terminal & Ore Bin		X	X						
33	58	Powder House								X	
34	59	Falcon Adit Portal					X				
35	60	Falcon Mine Ore Bin			X						
36	61	Pelican Lode Storage Sheds			X						
37	62	Phoenix Lode Storage Shed & Powder House			X						
38	63	Eureka Lode Adit Portal					X				
39	64	Woods Hole Adit Portal					X				
40	65	Partially Collapsed Log Storage Shed		X	X						
41	66	South Park Adit Portal							X		
42	67	Catskill Lode Adit & Storage Shed			X						
43	68	Gertie Lode Prospect Pit		X			X				
44	69	Catskill Lode Storage Building			X						
45	70	Operating Transformer Station									X
46	71	Union Carbonate Tram & Ore Bin							X	X	
47	72	Forest-Payroll Tram Tower & Ore Bin		X	X						
48	73	Silver Creek Mill Powder House		X	X						
49	89	Non-Operating Transformer Station			X						
50	90	Larson Tunnel Ventilation Raise		X			X				
51	91	Ore Bin			X						
52	92	Storage Shed		X	X						
53	93	Blain Tunnel							X		
54	94	Argentine Haulage Adit Portal		X			X		X		
55	95	Argentine Tunnel Portal							X		
56	96	Nutmeg Lode Tunnel Portal							X		
57	97	Nutmeg Lode Adit Portal					X				
58	98	Mountain Spring Mine Tram Tower		X	X						
59	99	Mountain Spring Mine Tram Tower		X	X						
60	100	Shed & Ore Bin		X	X						
61	101	Mountain Spring Mine Tram Tower & Ore Bin			X						
62	102	Mountain Spring Mine Tram Tower			X						
63	103	Mountain Spring Mine Snow Shed Ore Bin			X						
64	104	Mountain Spring Mine Powder House			X						
65	105	Mountain Spring Mine Non-Operating Transformer Station			X						
66	106	Mountain Spring Mine Non-Operating Transformer Station			X						
67	107	Mountain Spring Mine Tunnel Portal		X			X				
68	108	Mountain Spring Mine Mill & Office			X						
69	110	Mountain Spring Mine Sawmill, Storage Shed,			X						

RICO SITE
HAZARDS ELIMINATION PROGRAM

			Site Rehabilitation		Demolition	Optional Closure Techniques		Mandatory Closure Techniques		Special Hazard Elimination Techniques	
			Topsoil Application	Fertilize, Seed & Mulch	Remove & Dispose	Concrete Cap	Doze & Seal	Bulkhead W/Drain	Sealed Bulkhead	See Key for Details	Perimeter Fencing
		Snowshed, Ore Chute, Outhouse									
70	111	Mountain Spring Mine Ore Bin & Tram Tower			X						
71	112	C.V.G. (Burns) Mine w/Drainage			X						
72	113	Princeton Shaft		X			X				
73	114	Black George Adit Portal					X				
74	115	Wellington Mine			X						
75	116	Wellington Tunnel Portal w/Drainage							X		
76	117	Logan Shaft		X			X				
77	118	Nutmeg Lode Adit Portal					X				
78	119	Silver Creek Tailings Office			X						
79	120	Non-Operating Transformer Station			X						
80	121	Smuggler Adit Portal w/Drainage			X						
81	122	Collapsed Adit Portal			X						
82	123	Yankee Boy Shaft			*	X					
83	124	Collapsed Adit w/numerous roof collapses & surface pits			X						
84	125	Collapsed Adit Portal			X						
85	129	Hard Scrabble Adit Portal		X			X				
86	160	Rico Argentine Storage Building	X	X	X						
87	161	Black Hawk Adit		X					X		
88	163	Argentine Adit w/Concrete Portal		X			X				
89	164	Collapsed Stope "Daylighting" to surface		X		X					
90	165	Camp Housing Shed		X	X						
91	166	VanWinkel Shaft, Headframe & Hoist House			*					X	
92	167	VanWinkel Ore Bin			X						
93	168	VanWinkel Shaft Mine Buildings		X	X						
94	169	VanWinkel Shaft Mine Residence Buildings		X	X						
95	170	VanWinkel Planer Building			X						
96	171	L. P. Gas Stream Crossing			X						
97	172	Dilapidated Residential Unit		X	X						
98	173	Planer Building & Shed	X	X	X						
99	174	Last Chance Lode Adit Portal		X			X				
100	177	Protection No. 4 Lode			X						
101	178	Payroll Lode Adit		X			X				
102	179	Forest - Payroll Adit							X		
103	181	Forest - Payroll Ore Bin			X						
104	182	Dilapidated Shed			X						
105	183	Union Carbonate Aerial Tram Guide Wire			X						
106	184	Depot Foundation		X	X						
107	185	Junk Cars			X						
108	186	Dilapidated Bridge			X						
109	187	Wakeman Tunnel Shed			X						
110	188	Wood Debris Pile			X						

*Optional Disposal Site.

7-Analysis of St. Louis Tunnel Flow Data

SEH MEMORANDUM

TO: File

FROM: Alan Jewell, P.E.

DATE: December 5, 2005

RE: Analysis of existing data on St. Louis Tunnel Flow Sources
SEH No. AARCOE0105.00

A preliminary analysis of known existing flow data has been performed. The analysis consists of a water balance of various known and potential contributors of flow to the St. Louis Adit outflow. Only two sources of data regarding internal flows within the mine have been examined. Other flow measurements are known to have been taken, but have not yet been acquired. The sources examined consist of three internal Anaconda memos, one by E. F. Sass, one by C.S. Sra, and one by Jack Whyte (copies attached). The memos contain valuable flow information, but their lack of specifics as to exactly what flows were measured is problematic.

Preliminary Water Balance Model

A water balance model was developed to attempt to reconcile the two sources of flow measurement. Various known or potential sources of inflow (and outflow) to/from the mine workings have been identified, along with some details of the "plumbing" that routes these flows to the St. Louis Adit. The water balance model is presented in Figures 1 and 2. The model is composed of several submodels. The "Underground Model" models the known or assumed plumbing of the mine based on reconstructed 3D models of the facility (Figures 3 and 4). The "Source Model" models the numerous known and potential contributors to flow. Various other models tie the two models together, mapping source contributions to various parts of the mine.

Model Calibration and Analysis

The model is calibrated against data from the Whyte and Sass memos, assumptions about what specific flows the memos are referring to, as well as numerous physical assumptions. The important assumptions are listed below:

Data Assumptions

- It is not known whether the total flow referred to by Whyte is at the St. Louis Adit or within the tunnel. A location within the tunnel where the north and southeast crosscuts confluence is assumed. Whyte is otherwise clear and provides data on sources of flow from various conduits intersecting the St, Louis Tunnel.
- The Sass memo indicates that 20-30% or more (200-300 gpm) of the total flow is from drillholes within the mine. Sass indicated that attempts were being made to plug the holes, but was skeptical that the water would not reemerge somewhere else. Sass also does not indicate where in the mine the all of the drillholes are (except that one is in the Blaine), however, the earlier Sra memo indicates all of the flowing drillholes are in the Rico-Argentine Adit. Sass does not appear to indicate a distinction between the Rico-Argentine and Blaine workings. It is assumed that Sass

refers the Rico-Argentine/Blaine Group as the "Blaine," and that all of the flowing drillholes observed by Sass and Sra are in the Rico-Argentine.

- The Sass memo also indicates 350-400 gpm of flow is emerging from the Blaine, but does not indicate exactly where this was measured, or whether it includes the drillholes presumably in the Rico-Argentine Adit. Sass indicates that 300-400 gpm of the above total was traced "as far as the [Blaine] workings were accessible and typically ended with water entering through a collapsed raise or drift from caved stopes above in the highest level of the mine." It is assumed that since the drillhole flows are observable (not hidden in collapsed workings), that the 350-400 gpm emerging from the "Blaine" is separate from the 200-300 gpm emerging from the drillholes. It is also assumed that the 350-400 gpm is flowing from collapsed portions of the Blaine and/or Rico Argentine. It is further assumed that Sass estimated this flow at the Blaine level and above, as opposed to the St. Louis Level at the 517 shaft or higher.
- It is assumed that the Rico-Argentine workings all flow to the St. Louis Tunnel, and that no flow emerges from the Rico-Argentine Adit (significant flow emerging from the adit would probably have been previously observed or noted by Sass and Sra if present).

Model Assumptions

- The various source and flow assumptions are given in Figures 1 and 2.
- Faults intersecting the surface (Figure 5) are assumed to be a source of inflow. The amount of inflow is assumed to be a function of the length of the fault, the surface area of drainage to the fault, and the extent of the workings potentially acting as drainage. Other than the length of the faults, none of the other parameters are quantified except by eyeball estimate. Thus, relative contributions from fault infiltration are estimated for various faults and parts of the mine. The model is allowed to solve for the total quantity infiltrating via faults.
- Where Silver Creek or the Dolores River cross faults, they are assumed to be potential sources of inflow and/or outflow. The relative contributions of each of these crossings could be estimated based on judgment of their closeness to the workings, head relative to the workings, and other factors; however, it is not apparent whether they would result in inflow or outflow. It is therefore assumed that where the Blackhawk fault crosses Silver Creek is the only contributor. The model solves for the magnitude and direction of the flow.
- Historic shafts are assumed to be potential contributors. Since little information is available about them, they are all assumed to contribute a relative amount proportional to their apparent drainage area (Figure 5). Some are known to be capped, but presumably could still be influenced by shallow groundwater. It is not clear which, if any of the shafts shown on Figure 5 are connected to the mine system, so all are presumed to be connected equally. The model solves for the total amount of flow from all shafts.
- Regional groundwater is presumed to contribute to inflow. The relative amount contributed to various parts of the mine is based on an eyeball estimate based on potential contributing area and extent of mine workings for each part of the mine.
- Drillholes within the mine are located based on the assumptions described previously. Some of the drillholes are presumed to be influenced by very deep groundwater since they are believed to have been associated with the molybdenum deposit exploration. The model is allowed to solve for the portion of drillhole inflow derived from deep groundwater.

<u>Model Results</u>

The model solves for the total relative contributions of the various sources described above, while best-fitting model results to the known data. The results of the model are presented in Figure ? and summarized below:

- The model predicts the following relative source contributions:
    - Silver Creek: 5% of total flow
    - Fault Infiltration: 68% of total flow (including above)
    - Regional groundwater: 20% of total flow (as a loss)
    - Drillholes: 21% of total flow, with 100% from deep ground water
    - Shafts: 33% of total flow

<u>Conclusions</u>

The model is able to fit the observed data very closely, however, more data and/or model constraints are needed to obtain a reliable picture of the contributing sources of flow to the St. Louis Adit discharge. The model likely has some conceptual errors with regard to handling of the flow from drillholes, but until more information is gathered on the nature of these drillholes, it probably makes no sense to adjust the model. It seems unlikely that 100% of the drillhole water is from deep sources, however, the Rico-Argentine Group appears to produce an excess of water that the existing model attempts to explain by suggesting it is from sources other than the surface.

The model seems to indicate that potential infiltration from Silver Creek is minor, but this is a tentative conclusion until the model can be improved. Unless the model is improved, field confirmation is probably necessary. Field confirmation of creek/river infiltration should consider the possibility of multiple sources. Improvements to the existing model could be made as described below:

- **Collect and add more data.** More data regarding internal flows is known to have been collected. If this data can be located, it can likely be used to improve the model. Data on the drillholes should be included as well.
- **Improve the physical model.** Improved estimates of the relative contributions from various sources can be obtained. For instance, the fault infiltration can take into account storage in surficial deposits as well as hydraulics of entrance to the fault, giving greater precision as to the relative importance of various faults. River/creek infiltration could be described physically as well.
- **Fieldwork.** The proposed examination of shafts, adits and other potential sources of inflow or outflow in the field should allow further constraints to be imposed on the model.
- **Improve the ground water portion of the model.** Better assumptions of the magnitude of various ground water contributors can and should be made. The computed loss of ground water seems very high relative to the Dolores basin as a whole, however certain mine workings (the 600 level) are known to be flooded.
- **Calibration of model against St. Louis Tunnel Outflows.** A previously developed model of total flow from the St. Louis Tunnel was developed. The only input to the model was flow in the Dolores River. St. Louis Tunnel flows were modeled surprisingly well when a simple "leaky storage tank" assumption was used to correlate Dolores River flows to St. Louis Tunnel flows. In other words, the St. Louis Tunnel flow responds similarly to the Dolores River flow, except that the St. Louis Tunnel seems to have a slightly extended runoff curve – it acts as a leaky storage tank. It is believed that the model developed herein could replace the storage tank model and be more accurate if physical and time-based submodels of fault infiltration, surface infiltration and

creek/river infiltration could be developed. With some estimate of the time element included for various sources, a more accurate picture of the size of various contributors could be made. For instance, ground water infiltration, fault infiltration, shaft infiltration and river/creek infiltration are all expected to have different significantly different flow vs. time signatures. The developed model would also be useful in improving the tunnel outflow model for the treatment phase of the project.

- **Water Chemistry.** Water chemistry data within the mine is included in the previously referenced memos, but is subject to the same assumptions described previously. This data is currently being added to the database. Additional data is known to have been collected and will be acquired if possible. Due to the likely changes in chemistry as water flows through the mine, it is unknown whether this data will provide a reliable mass balance estimate if no chemical changes are assumed. However this data could assist in discerning clues as to the internal mine chemistry once flows are more accurately calculated. This would likely prove useful in the final assessment of the benefit of air doors.
- **Sensitivity or Statistical Analysis.** Once the model is improved, a sensitivity or statistical analysis could be performed to assess the impact of various remaining assumptions. The estimated probability of various assumptions could be included, for example.

8-Blaine Adit - Data Summary 1

Station	DateTime	Consultant	Laboratory	Analyte	AnalyteTy	AnalyteMe	Value	Qualifier	Units	DataSourceName	ElectronicFileSource	Comment:	EntryID
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	1.9		standard u	24	Blaine Adit.xls	Preserved	2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	0.06		mg/l	24	Blaine Adit.xls		2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	253		mg/l	24	Blaine Adit.xls		2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	1.96		mg/l	24	Blaine Adit.xls		2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	5.4		mg/l	24	Blaine Adit.xls		2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.001	U	mg/l	24	Blaine Adit.xls		2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
Swan Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00005		mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	1.8		standard u	24	Blaine Adit.xls	Preserved	2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	1.7		mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	769		mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	1.78		mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	13.2		mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.007		mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
Blaine Tunnel @ Collar of Blaine Shaft	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00005		mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	3.1		standard u	24	Blaine Adit.xls	Preserved	2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	0.3		mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	393		mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	1.58		mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	0.3		mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.005		mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
Santa Cruz - Decline Collar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00005		mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	1.8		standard u	24	Blaine Adit.xls	Preserved	2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	4.3		mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	562		mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	5.2		mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	16.2		mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.022		mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
Total Discharge - St. Louis Portal	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00005		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	1.7		standard u	24	Blaine Adit.xls	Preserved	2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	2.7		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	544		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	2.62		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	3.7		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.009		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the SE D	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00005		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	2		standard u	24	Blaine Adit.xls	Preserved	2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	18		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	1070		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	27		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	102		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.107		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.13		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge from the Nort	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00005		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	1.8		standard u	24	Blaine Adit.xls	Preserved	2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	1.7		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	505		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	0.5		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	5.6		mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.001	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Tunnel Discharge 145 Raise Ar	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Not Applic	0.00007		mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	7.6		standard u	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	5.6		mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	670		mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	1.28		mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	0.13		mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.007	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applic	Unknown	0.00005		mg/l	24	Blaine Adit.xls		2453180
St. Louis Settling Ponds Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cyanide	Not Applic	Not Applic	0.01	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	pH	Not Applic	Not Applic	7		standard u	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Flouride	Not Applic	Not Applic	5.8		mg/l	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Sulfate	Not Applic	Not Applic	620		mg/l	24	Blaine Adit.xls		2453180

St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Zinc	Total	Unknown	5		mg/l	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Iron	Total	Unknown	12.8		mg/l	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Cadmium	Total	Unknown	0.029		mg/l	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Lead	Total	Unknown	0.05	U	mg/l	24	Blaine Adit.xls		2453180
St. Louis Adit Discharge	8/18/1980	Rico Argentine Mining Co.	Commercial Testing and Engineering	Mercury	Not Applica	Unknown	0.00005		mg/l	24	Blaine Adit.xls		2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Cadmium	Total Reco	Unknown	0.73		mg/l	25	Blaine Adit.xls	Method 21	2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Copper	Total Reco	Unknown	21		mg/l	25	Blaine Adit.xls	Method 20	2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Lead	Total Reco	Unknown	0.56		mg/l	25	Blaine Adit.xls	Method 23	2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Silver	Total Reco	Unknown	0.0011		mg/l	25	Blaine Adit.xls	Method 27	2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Zinc	Total Reco	Unknown	130		mg/l	25	Blaine Adit.xls	Method 20	2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Flow	Instantane	Not Applica	15		gpm	25	Blaine Adit.xls	Approxima	2453180
Blaine Adit	6/3/1987	Anaconda Minerals Company	Enseco	Mercury	Total	Not Applica	0.0001		mg/l	25	Blaine Adit.xls	Method 24	2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.02		mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	0.005		mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.001		mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.001	U	mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.005	U	mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	36		mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	0.2		mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
Dolores River, Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applica	Not Applica	8.21		standard u	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.015		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	1.38		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.005		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.01		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.001		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.005	U	mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	587		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	2.32		mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
St. Louis Tunnel	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applica	Not Applica	7.53		standard u	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.013		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	1.38		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.007		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.001	U	mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	870		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	1.35		mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
Blaine Adit	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applica	Not Applica	6.7		standard u	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.035		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	0.056		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.009		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.026		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.002		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	934		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	1.26		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.03		mg/l	26	Blaine Adit.xls		2453180
Well DB-6	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applica	Not Applica	6.94		standard u	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.021		mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	0.9		mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.004		mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.007		mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.001		mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls		2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	664		mg/l	26	Blaine Adit.xls		2453180

Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	0.9		mg/l	26	Blaine Adit.xls	2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Settling Pond	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applic:	Not Applic:	7.61		standard u	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Total	Unknown	0.188		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Total	Unknown	0.9		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Total	Unknown	0.006		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Total	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Total	Unknown	0.005		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Total	Unknown	0.001		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Total	Unknown	0.005	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Total	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Total	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Dissolved	Unknown	0.013		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Dissolved	Unknown	0.84		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Dissolved	Unknown	0.002		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Dissolved	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Dissolved	Unknown	0.005		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Dissolved	Unknown	0.001		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Dissolved	Unknown	0.005	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Dissolved	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Dissolved	Unknown	725		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Dissolved	Unknown	2.45		mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Dissolved	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Pond Discharge	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applic:	Not Applic:	7.43		standard u	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.015		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	0.083		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.001		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.001		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.005	U	mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	115		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	0.5		mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Dolores River, Below Operations	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applic:	Not Applic:	7.55		standard u	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Iron	Unknown	Unknown	0.016		mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Zinc	Unknown	Unknown	0.006		mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Copper	Unknown	Unknown	0.003		mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Lead	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Cadmium	Unknown	Unknown	0.001	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Silver	Unknown	Unknown	0.001	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Nickel	Unknown	Unknown	0.005	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Mercury	Unknown	Unknown	0.0002	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Sulfate	Unknown	Unknown	4.1		mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Flouride	Unknown	Unknown	0.1	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	Arsenic	Unknown	Unknown	0.01	U	mg/l	26	Blaine Adit.xls	2453180
Silver Creek Above Operations	8/14/1978	Anaconda Minerals Company	Unknown	pH	Not Applic:	Not Applic:	8.3		standard u	26	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Cadmium	Total Reco	Unknown	1600		ug/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Copper	Total Reco	Unknown	26000		ug/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Flow	Not Applic:	Not Applic:	2		gpm	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Lead	Total Reco	Unknown	770		ug/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Mercury	Not Applic:	Not Applic:	0.2	U	ug/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Silver	Total Reco	Unknown	5.2		ug/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	TSS	Not Applic:	Not Applic:	10	U	mg/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Colorado Department of Health	Water Lab No. 902545	Zinc	Total	Unknown	220000		ug/L	27	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	pH	Not Applic:	Not Applic:	1.97		standard u	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	TDS	Not Applic:	Not Applic:	7654		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	TSS	Not Applic:	Not Applic:	1		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	Cadmium	Total	Unknown	1.57		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	Copper	Total	Unknown	25		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	Lead	Total	Unknown	2.7		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	Zinc	Total	Unknown	195		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	Silver	Total	Unknown	0.011		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	5/17/1990	Rico Development	IML	Mercury	Total	Unknown	0.0009		mg/l	28	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applic:	Not Applic:	2.47		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	TDS	Not Applic:	Not Applic:	12056		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	TSS	Not Applic:	Not Applic:	2		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	Cadmium	Total	Unknown	1.68		mg/l	29	Blaine Adit.xls	2453180

Blaine Adit	6/12/1990	Rico Development	IML	Copper	Total	Unknown	34.1		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	Lead	Total	Unknown	1.76		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	Zinc	Total	Unknown	239		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	Silver	Total	Unknown	0.0039		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Rico Development	IML	Mercury	Total	Unknown	0.0002	U	mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.4		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	TDS	Not Applica	Not Applica	12198		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	TSS	Not Applica	Not Applica	7.5		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	Cadmium	Total	Unknown	1.84		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	Copper	Total	Unknown	33.5		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	Lead	Total	Unknown	1.03		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	Zinc	Total	Unknown	255		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	Silver	Total	Unknown	0.0032		mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Rico Development	IML	Mercury	Total	Unknown	0.0002	U	mg/l	29	Blaine Adit.xls	2453180
Blaine Adit	6/5/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	2.4		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/6/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	2.4		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/7/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	2.6		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/8/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	3		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/9/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	3.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/10/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	3.8		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/11/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	3.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	3.6		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/13/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	2.4		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/14/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	2.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/15/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1.6		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/16/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1.4		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/17/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/19/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/20/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/21/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1.2		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/22/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/23/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.1		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/24/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	1		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/25/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.9		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/26/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.9		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/27/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.75		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/28/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.75		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/29/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.75		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/30/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Flow	Not Applica	Not Applica	0.75		gpm	30	Blaine Adit.xls	2453180
Blaine Adit	6/5/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	3.26		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/6/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	3.63		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/7/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	3.54		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/8/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.24		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/9/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.75		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/10/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.54		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/11/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.44		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.82		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/13/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	3.09		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/14/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.27		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/15/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.25		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/16/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.25		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/17/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.34		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.23		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/19/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.26		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/20/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.54		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/21/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.58		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/22/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.57		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/23/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.58		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/24/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.62		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/25/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.45		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/26/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.51		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/27/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.61		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/28/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.5		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/29/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.62		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/30/1990	Michael Towne - Rico Properties?	NA - Field Measurement	pH	Not Applica	Not Applica	2.57		standard u	30	Blaine Adit.xls	2453180
Blaine Adit	6/5/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applica	Not Applica	2.4		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/6/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applica	Not Applica	2.5		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/7/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applica	Not Applica	2.3		Deg C	30	Blaine Adit.xls	2453180

Blaine Adit	6/8/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	4.8		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/9/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	3.4		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/10/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	5.4		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/11/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	4.3		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/12/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	4.4		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/13/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	2.2		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/14/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	10.6		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/15/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6.7		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/16/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	2.4		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/17/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	1.2		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/18/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	3.1		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/19/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6.2		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/20/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	1.8		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/21/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	5.2		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/22/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/23/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6.8		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/24/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6.8		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/25/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/26/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6.2		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/27/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/28/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	6.5		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/29/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	5.8		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/30/1990	Michael Towne - Rico Properties?	NA - Field Measurement	Temperatu	Not Applic	Not Applic	5		Deg C	30	Blaine Adit.xls	2453180
Blaine Adit	6/27/2000	ESA	NA - Field Measurement	Flow	Not Applic	Not Applic	1.6		gpm	22	Blaine Adit.xls	2453180
Blaine Adit	6/27/2000	ESA	NA - Field Measurement	pH	Not Applic	Not Applic	1.97		Standard	22	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Cadmium	Total Reco	Unknown	1480		ug/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Copper	Total Reco	Unknown	33000		ug/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Lead	Total Reco	Unknown	180		ug/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Mercury	Not Applic	Not Applic	0.63		ug/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Silver	Total Reco	Unknown	4	U	ug/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	TSS	Not Applic	Not Applic	18		mg/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Zinc	Total	Unknown	220000		ug/L	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	pH	Not Applic	Not Applic	2.76		standard u	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Flow	Not Applic	Not Applic	1.1		gpm	31	Blaine Adit.xls	2453180
Blaine Adit	5/7/2001	Colorado Department of Public Health & Environmen	Inorganic Chemistry Laboratory	Temperatu	Not Applic	Not Applic	10		Deg C	31	Blaine Adit.xls	2453180

9-Blaine Adit – Data Summary 2

Blaine Adit

3.276792873

Station	Short Name	Description	DateTime	Parameter	Value	Units	AnalyteType	Consultant
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	Lead	5	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	Temperature	20	Deg C	Water	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	Cadmium	10	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	Mercury	0.9	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	Zinc	920	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	pH	7.4	standard units	Not Applicable	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	9/28/1977	Copper	50	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Lead	30	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Temperature	12.5	Deg C	Water	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Cadmium	5	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Silver	5	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Mercury	0.1	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Zinc	843	ug/L	Total	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Flow	2.12	mgd	Instantaneous	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	pH	6.6	standard units	Not Applicable	USEPA REGION 8
CO-0029793-1	SC-2	DISCHARGE 001 AT BLAINE TUNNEL	6/26/1985	Copper	5	ug/L	Total	USEPA REGION 8
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Lead	99	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Lead	99	ug/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Lead	99	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Cadmium	2000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Cadmium	2000	ug/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Cadmium	2000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Silver	1.5	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Silver	1.5	ug/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Silver	1.5	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Zinc	489000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Zinc	489000	ug/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Zinc	489000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	TDS	11400	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Hardness	2025	mg/L	Unknown	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Hardness	2025	mg/L	Unknown	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Copper	50000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Copper	50000	ug/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Copper	50000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Manganese	115000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Manganese	115000	ug/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Manganese	115000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Iron	1500000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Iron	1500000	ug/L	Dissolved	SEH/ESA

SC-2	SC-2	Blaine Adit Discharge	10/25/1999	Iron	1500000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	10/25/1999	TSS	18	mg/L	Total	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Lead	505	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Lead	505	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Lead	505	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Cadmium	7000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Cadmium	7000	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Cadmium	7000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Silver	1.4	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Silver	1.4	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Silver	1.4	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Zinc	230000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Zinc	230000	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Zinc	230000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Sulfate	330	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Flow	1162.392	gpm	Instantaneous	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	TDS	7089	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Hardness	2149	mg/L	Unknown	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Hardness	2149	mg/L	Unknown	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Copper	5200	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Copper	5200	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Copper	5200	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Manganese	149000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Manganese	149000	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Manganese	149000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Iron	844000	ug/L	Dissolved	Unknown
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Iron	844000	ug/L	Dissolved	SEH QA/QC
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	Iron	844000	mg/L	Dissolved	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	6/27/2000	TSS	6	mg/L	Total	SEH/ESA
SC-2	SC-2	Blaine Adit Discharge	11/3/2003	Flow	0	gpm	Instantaneous	SEH/Sugnet
SC-2	SC-2	Blaine Adit Discharge	12/3/2003	Flow	0	gpm	Instantaneous	SEH/Sugnet
SC-2	SC-2	Blaine Adit Discharge	1/8/2004	Flow	0	gpm	Instantaneous	SEH/Sugnet
SC-2	SC-2	Blaine Adit Discharge	2/4/2004	Flow	0	gpm	Instantaneous	SEH/Sugnet
SC-2	SC-2	Blaine Adit Discharge	3/3/2004	Flow	0	gpm	Instantaneous	SEH/Sugnet
SC-2	SC-2	Blaine Adit Discharge	4/28/2004	Flow	0	gpm	Instantaneous	SEH/Sugnet
SC-2	SC-2	Blaine Adit Discharge	12/8/2004	Flow	0	gpm	Instantaneous	SEH/Sugnet

10-Comparison Blaine – St. Louis

Zinc (all values in ug/L)							
DateTime	DR-3 - St_ Louis Adit, at portal	SC-2 - Blaine Adit Discharge	St_ Louis 145 Raise	St_ Louis Iron Rod Raise SW Side	St_ Louis North Drift	St_ Louis SE Crosscut Drill Hole	St_ Louis SE Drift
9/28/1977		920					
8/14/1978	1380	1380					
7/26/1979	6990						
8/18/1980	5200	1780	5000		27000		2620
8/25/1980	5200						
11/10/1980	3400						
12/1/1980	3000						
12/11/1980	1400						
5/21/1981	5200						
6/15/1981	7110						
6/16/1981	7110						
11/1/1981	1860						
7/24/1982	2500						
9/1/1982	2990						
6/26/1985		843					
8/27/1985		27000		1000	27000	3500	
6/3/1987		130000					
5/17/1990		220000					
6/12/1990		239000					
6/18/1990		255000					
6/1/1995	10600						
8/15/1995	4400						
10/24/1999	6870						
10/25/1999	6870	489000					
6/26/2000	3670						
6/27/2000		230000					
5/7/2001		220000					
6/27/2001	4510						
10/18/2001	3890						
7/16/2002	3430						
10/8/2002	3200						
10/30/2003	5190						
12/2/2003	4280						
1/7/2004	3650						
2/3/2004	3690						
3/2/2004	3750						
4/27/2004	4180						
6/1/2004	13900						
7/6/2004	6230						
12/7/2004	4930						
	U						
	K						
	B						
Value	More than one value for same date; highest value is shown						

11-St. Louis Underworkings – Miscellaneous Notes – Water Rights

Water Rights

Diamond Drill Holes

Drill Hole	Location	N.M.P.M. Bearing	Distance (ft)	Flow (gpm)	Water Right Established	Reference	Reference Location
M-9	SE Corner of Section 23, T40N, R11W	N22^{o}-05'W	2954	160	9/26/1972	Letter from Rico Argent	Rico, Colorado Artesian Drill Holes 1980 Folder
BB-6	SE Corner of Section 23, T40N, R11W	N16^{o}-26'W	2925.7	200	8/16/1975	Letter from Rico Argent	Rico, Colorado Artesian Drill Holes 1980 Folder
BB-7	SE Corner of Section 23, T40N, R11W	N22^{o}-25'-30'W	3219.1	120	11/5/1975	Letter from Rico Argent	Rico, Colorado Artesian Drill Holes 1980 Folder
OS4	SE Corner of Section 23, T40N, R11W	N17^{o}-36'W	3243	0.055	1/1/1972 (Historic Date: 10/31/1970)	Ruling of Referee: Appli	101.9502 Rico Site Tech Support: Water Rights
OS5A	SE Corner of Section 23, T40N, R11W	N18^{o}-44'W	3458	0.055	1/1/1972 (Historic Date: 11/30/1971)	Ruling of Referee: Appli	101.9502 Rico Site Tech Support: Water Rights

Locations of drill holes placed on St. Louis Underworkings.dwg map using maps attached to letter from R.L. Dent to J. Whyte on October 9, 1980 (Rico, Colorado Aretsian Drill Holes 1980 Folder)

Other

Diversion	Location	N.M.P.M. Bearing	Distance (ft)	Flow (gpm)	Water Right Established	Reference	Reference Location
Blaine Tunnel	SE Corner of Section 23, T40N, R11W	N64^{o}-10'W	7515	0.4995	1/1/1972 (Historic Date: 12/31/1937)	Letter from Rico Argent	Rico, Colorado Artesian Drill Holes 1980 Folder
St. Louis Tunnel	SE Corner of Section 23, T40N, R11W	N54^{o}-51'W	1092	1.1942	1/1/1972 (Historic Date: 12/31/1929)	Letter from Rico Argent	Rico, Colorado Artesian Drill Holes 1980 Folder

12-Geology and Ore Deposits of the Rico District, Colorado

Geology and Ore Deposits of the Rico District, Colorado

By EDWIN T. McKNIGHT

GEOLOGICAL SURVEY PROFESSIONAL PAPER 723

A discussion of the geology and potential of a famous old silver camp which, under modern mineral technology, became a lead, zinc, and pyrite camp

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1974

spruce at higher levels are dominant types. The timberline is at about 11,500 feet.

Although some mineralized ground is on the west side of the river opposite Rico, the major production from the district has come from mines east of the river. Some of these mines have been in blocks of ground mantled by thick wash and landslide debris. Because of their importance as mining areas, some of these mantled lower slopes of the mountains have been given special names. Thus, CHC Hill is the lower west slope of Telescope Mountain, and Newman Hill is the lower west slope of Dolores Mountain. The major mineral production has come from CHC Hill; from Nigger Baby Hill, which is the long spur that extends southwest from Telescope Mountain and overlooks Rico; from the valley of Silver Creek about 1½ miles northeast of Rico; and from Newman Hill.

In the early production of the district, silver was the major economic product; but upon depletion of the rich silver ores, lead, zinc, and, to a less extent, copper have been the main products, and silver has been an important byproduct. Gold has always been a significant byproduct, and at least one small mine has been worked exclusively for this metal. In 1955 a plant was built for production of sulfuric acid from massive pyrite ores, and in the next 9 years a substantial amount of acid was produced for use in uranium mills of the adjacent Colorado Plateau.

HISTORY

The early history of the Rico mining district has been given by Ransome (1901, p. 238–242) and therefore is only summarized here. The first claim was staked in 1869 on ground along the river at Rico, including parts of what later became the Shamrock, Smuggler, and Riverside claims. In the next 10 years, additional claims were staked within the Rico town area, on Nigger Baby Hill, in the mineralized area up Silver Creek, and in Aztec Gulch. Development work was intermittent, however, and the claims were commonly abandoned on the approach of winter.

In 1879, oxidized silver ores were discovered on Nigger Baby Hill which were rich enough to attract a sharp influx of prospectors into the district. A mining settlement sprang up, civil government was organized, and a post office was established at Rico. In the same year, ore was discovered and shipped from one of the veins in Newman Hill. General activity in the camp increased over the next few years. In 1880 a small smelter was built on the east bank of the Dolores River at the north edge of town to treat the ores from the Grandview mine, but it proved to be short lived. A second smelter was built at the southern end of town, beginning in 1882, and operated as a custom plant for nearly 2 years during 1884–86. Silver production rose to a temporary peak of 193,360 ounces in 1883, but it sagged appreciably in the next 3 years.

In 1887 a prospect shaft on the Enterprise claim, by pure accident, struck the edge of the largest and richest ore body ever found on Newman Hill. This was a blanket ore body of a type that proved to be very productive of rich silver ore during the next few years, as further ore bodies were explored and opened in the extension of mining from this initial discovery. The Enterprise success stimulated development throughout the camp, and within the next few years ore had been developed in all the mineralized areas that are now known, including CHC Hill. The Rio Grande Southern Railroad Co. completed a narrow-gage line into the camp in 1890, and within a short time spur lines were operating up Silver Creek and to the portal of the Enterprise Group tunnel.

The all-time peak of silver production was reached in 1893, 2,675,238 ounces, of which the mines in Newman Hill, particularly the Enterprise mine, contributed the largest share. The drop in silver prices during the 1890's, and particularly the famous silver panic in mid-1893, affected Rico as it did all other western mining camps, and the production fell sharply in the next few years. Yet the fundamental cause for the decline as a silver camp was depletion of the rich silver ores. By the time of the Ransome (1901) report, the Newman Hill mines were largely exhausted of all except low-grade base-metal ores.

In the early 1900's, other parts of the district became relatively more productive, and by 1905 for the first time the combined values of lead and zinc produced in the district exceeded that of silver. Activity in the district waxed and waned with the economics of mining during the next several years, but there was substantial development and production each year. The demands for base metals before and during World War I stimulated the mining of base-metal ores, particularly in CHC Hill and in the mineralized area up Silver Creek. However, peaks of production generally depended on the fortunes of ore discovery. A temporary peak for base metals was reached in 1913 when the district produced 400 tons of copper, 1,540 tons of lead, and 1,300 tons of zinc. Although the output of lead and zinc fluctuated at a lower level in the next few years, the all-time peak production of copper, 516 tons, was reached 2 years later, principally from the Mountain Spring-Wellington mine of the Rico-Wellington Mining Co.

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in CHC Hill. Mining economic conditions began to deteriorate during the last year of the war, and production reached a low ebb by 1921.

In the mid-1920's the mining industry at Rico revived, chiefly through advances in the metallurgical industry. Perfection of the flotation process in the previous decade had made attractive such complex sulfide ores as prevail at Rico, and the mine operators were, for the first time, able to realize a fair profit on the zinc content of their ores instead of being penalized for it as in past years. At first, the ores were shipped to new custom flotation mills in the Salt Lake area, Utah, but in 1926 a 250-ton custom mill was built at Rico by the International Smelting Co. (subsidiary of Anaconda Mining Co.), and for nearly 2 years most of the output of the district was concentrated in this mill. The chief producing companies included the Rico Argentine Mining Co., working the mineralized area up Silver Creek on the south side of the creek; the Falcon Lead Co., working the Yellow Jacket mine and other properties on Nigger Baby Hill; the Rico Mining & Reduction Co. and (after May 1927) its successor, the St. Louis Smelting & Refining Co., working CHC Hill, the Silver Swan mine below Rico, and a small part of the mineralized area along Silver Creek; the Pelleyre Mining & Milling Co. (subsidiary of International Smelting Co.), working the Shamrock and several other properties in the district; Union Carbonate Mines, Inc., working the Union Carbonate mine; and the Rico Enterprise Mining Co., working the Pro Patria and Revenue mines. The all-time peak of production for base metals was made in 1927 when the district output was 5,308 tons of zinc, 4,994 tons of lead, and 65 tons of copper. The mining boom was, however, relatively short lived. The custom mill at Rico operated only from October 1926 to July 1928, when it shut down permanently. Ore that continued to be produced for a time was shipped again to the custom mills at Salt Lake.

In 1929 mining at Rico was hit by the Depression, and by 1932, production had ceased. The St. Louis Smelting & Refining Co. drove its St. Louis tunnel and crosscut extensions into the east bank of the Dolores River under CHC Hill during the depth of the Depression (1930–32), but failed to reach the Mississippian and Devonian limestones in which deep replacement ores were prospective targets. Mining was resumed on a relatively small scale in 1934, and production from several mines fluctuated over the next few years.

In September 1939, the Rico Argentine Mining Co. finished a new 135-ton flotation mill and began a period of steady production that brought a degree of stability to the mining industry at Rico. This company was the major producer during World War II. The Van Winkle shaft was sunk on the east edge of town in 1942, and for several years supplied a large share of the Rico Argentine production. The company has maintained steady production, though not always at mill capacity, to the present day except for two periods, May 1949 to July 1950, and June 1957 to some time in 1959, when low base-metal prices made the operation uneconomic. The long crosscut from the St. Louis tunnel to the Argentine shaft on Silver Creek was finished in 1955, lowering the water level in the Silver Creek mine workings by about 450 feet and draining a large block of mineralized ground. At present, the company controls most of the mining properties from which the major past production of the district has come. Its mill capacity (1969) is rated at 150 tons per day.

In September 1955, the Rico Argentine Mining Co. completed and put in operation a plant for the production of sulfuric acid from pyrite. The acid was sold to several uranium mills operating in the adjacent part of the Colorado Plateau. The acid plant ran for 9 years, until a cutback in the uranium program destroyed the market for the acid. The plant was put on a standby basis in October 1964. Much of the acid production came at a period of low base-metal prices, when the entire mining facilities could readily be diverted to the mining of pyrite.

TRANSPORTATION FACILITIES

The narrow-gage railroad completed through Rico by the Rio Grande Southern Railroad Company in 1890 served the district for 60 years. In its later days, locomotive power was supplied by various models of converted automobile gasoline engines. Eventually, freight from the mining industry at Rico and Telluride was not enough to sustain the railroad, and it was finally abandoned as uneconomic in 1951. Since then, mining supplies have been brought in and concentrates taken out by truck. At present (1969), all concentrates are trucked to the Denver and Rio Grande Western Railroad line at Ridgway, Colo., where they are loaded into freight cars and shipped to the Bunker Hill Co. reduction plants at Kellogg, Idaho.

PRODUCTION

Table 1 gives the production of precious and base metals from the Rico district from 1879–1968.

Between September 1955 and October 1964, the acid plant produced 316,108 tons of commercial sulfuric acid, 100 percent basis. In the first year and a quarter, pyritic tailings from the lead-zinc mill

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TABLE 1.—*Gold, silver, copper, lead, and zinc produced in the Rico district, 1879–1968*

[Figures derived by subtracting from the production of Dolores County that of the Lone Cone district, which is the only other metal-producing district of record (1896–1941) in the county. Lone Cone production for 1896–1903 estimated (gold and silver only), for later years from unpublished statistical charts furnished by the U.S. Bur. Mines. Production of Dolores County for 1879–1923 from Henderson (1926, p. 117); for 1924–31, from annual volumes of U.S. Bur. Mines Mineral Resources of the United States; for 1932–62, from annual volumes of U.S. Bur. Mines Minerals Yearbook; for 1963–68, from unpublished statistics furnished by U.S. Bur. Mines. Compilation for Dolores County by Robert G. Luedke, U.S. Geol. Survey]

Year	Lode gold		Silver		Copper		Lead		Zinc		Total value
	Fine ounces	Value	Fine ounces	Value	Short tons	Value	Short tons	Value	Short tons	Value	
1879	73	$1,500	7,734	$8,662	2	$800	5	$410	----	----	$11,372
1880	169	3,500	30,938	35,579	14	6,206	50	5,000	----	----	50,285
1881	242	5,000	69,610	78,659	22	8,008	100	9,600	----	----	101,267
1882	484	10,000	85,078	96,989	27	10,314	100	9,800	----	----	127,103
1883	242	5,000	193,360	214,630	50	16,500	100	8,600	----	----	244,730
1884	73	1,500	54,141	60,097	--	----	76	5,624	----	----	67,221
1885	193	4,000	70,000	74,900	--	----	50	3,900	----	----	82,800
1886	414	8,561	75,836	75,078	--	----	396	36,432	----	----	120,071
1887	471	9,743	118,262	115,897	17	4,692	500	45,000	----	----	175,332
1888	845	17,470	123,852	116,421	--	----	500	44,000	----	----	177,891
1889	3,765	77,825	618,615	581,498	--	----	1,000	78,000	----	----	737,323
1890	7,561	156,297	848,785	891,224	--	----	1,000	90,000	----	----	1,137,521
1891	5,932	122,631	699,888	692,889	--	----	466	40,047	----	----	855,567
1892	11,401	235,669	1,285,179	1,118,106	7	1,513	1,542	123,327	----	----	1,478,615
1893	21,387	442,105	2,675,238	2,086,686	5	1,080	2,250	166,500	----	----	2,696,371
1894	9,318	192,626	1,153,325	726,595	15	2,850	1,000	66,000	----	----	988,071
1895	2,542	52,552	399,283	259,534	32	6,864	157	10,042	----	----	328,992
1896	216	4,465	221,393	150,547	--	----	550	33,000	15	$1,170	189,182
1897	603	12,464	104,901	62,941	20	4,758	547	39,378	----	----	119,541
1898	1,771	36,607	338,346	199,624	75	18,556	343	26,091	200	18,400	299,278
1899	1,234	25,508	157,052	94,231	22	7,611	1,023	92,080	50	5,800	225,230
1900	925	19,120	84,318	52,227	18	5,978	105	9,257	110	9,680	96,262
1901	179	3,700	66,632	39,979	7	2,189	184	15,783	125	10,250	71,901
1902	296	6,118	46,311	24,545	8	1,837	194	15,941	124	11,937	60,378
1903	293	6,056	45,096	24,352	74	20,220	72	6,024	----	----	56,652
1904	667	13,578	44,432	26,251	13	3,250	91	7,793	9	928	51,800
1905	206	4,250	29,496	18,275	60	18,692	420	39,495	278	32,820	113,532
1906	455	9,398	34,290	23,317	100	38,480	59	6,739	442	53,896	131,830
1907	132	2,734	20,317	13,409	50	19,899	27	2,891	----	----	38,933
1908	588	12,155	85,310	45,214	21	5,488	474	39,772	255	23,932	126,561
1909	514	10,641	64,375	33,475	22	5,621	230	19,756	84	9,049	78,542
1910	320	6,616	49,795	26,889	48	12,113	62	5,479	44	4,698	55,795
1911	23	475	30,842	16,346	2	373	350	31,476	263	29,944	78,614
1912	64	1,313	68,794	42,309	345	113,709	604	54,339	406	56,030	267,700
1913	306	6,333	153,111	92,479	400	124,057	1,538	135,332	1,298	145,389	503,590
1914	317	6,542	80,844	44,707	175	46,576	246	19,156	183	18,694	135,675
1915	524	10,828	122,664	62,190	516	180,670	134	12,593	18	4,456	270,737
1916	269	5,557	71,578	47,098	210	103,197	294	40,551	91	24,429	220,832
1917	252	5,213	88,222	72,695	260	141,937	886	152,411	851	173,538	545,794
1918	145	2,991	54,240	54,240	309	152,649	259	36,735	331	60,174	306,789
1919	122	2,517	35,084	39,294	132	49,284	49	5,231	34	4,893	101,219
1920	85	1,759	28,556	31,126	3	1,252	386	61,752	115	18,619	114,508
1921	68	1,401	10,524	10,524	1	96	9	838	----	----	12,859
1922	54	1,126	25,423	25,423	12	3,252	44	4,796	----	----	34,597
1923	56	1,154	33,471	27,447	28	8,336	81	11,331	69	9,384	57,652
1924	8	178	8,709	5,835	6	1,545	89	14,167	11	1,417	23,142
1925	83	1,722	37,994	26,368	23	6,674	908	157,975	1,053	160,056	352,795
1926	189	3,902	92,040	57,433	54	15,036	2,917	466,760	2,981	447,150	990,281
1927	411	8,488	173,395	98,315	65	17,161	4,994	629,230	5,308	679,360	1,432,554
1928	1,044	21,585	350,653	205,132	444	127,730	4,526	524,964	4,646	566,812	1,446,223
1929	532	11,016	268,783	143,261	164	57,596	3,530	444,739	2,952	389,730	1,046,342
1930	386	7,975	80,683	31,063	155	40,170	678	67,750	595	57,120	204,078
1931	34	697	1,648	478	1	182	35	2,553	41	3,116	7,026
1932	5	95	2	1	--	----	----	----	----	----	96
1933	40	817	4,820	1,687	1	51	3	222	----	----	2,777
1934	352	12,287	49,302	31,872	10	1,584	119	8,843	107	9,202	63,788
1935	656	22,944	71,040	51,060	13	2,075	140	11,220	142	12,452	99,751
1936	309	10,801	20,031	15,514	7	1,288	119	10,948	139	13,950	52,501
1937	188	6,566	13,086	10,122	7	1,694	125	14,697	136	17,680	50,759
1938	34	1,200	4,642	3,001	2	333	29	2,622	30	2,880	10,036
1939	121	4,235	41,356	28,072	65	13,416	752	70,688	867	90,168	206,579
1940	275	9,625	153,990	109,504	482	109,045	1,928	192,750	2,607	328,482	749,406
1941	102	3,570	112,715	80,153	62	14,632	2,525	287,833	3,004	450,600	836,788
1942	119	4,165	110,918	78,875	35	8,482	2,282	305,795	2,764	514,178	911,495
1943	127	4,445	145,021	103,126	72	18,785	2,566	384,900	3,652	788,832	1,300,088
1944	141	4,935	121,791	86,607	118	31,995	2,826	452,240	4,557	1,038,996	1,614,733
1945	157	5,495	152,266	108,278	86	23,220	2,440	419,680	3,920	901,600	1,458,273
1946	136	4,760	173,297	140,024	112	36,126	2,176	474,259	3,435	838,140	1,493,309
1947	104	3,640	124,199	112,400	109	45,591	2,042	588,168	3,433	830,883	1,580,682
1948	108	3,780	132,312	119,749	74	32,116	2,430	869,940	3,180	845,880	1,871,465
1949	79	2,765	80,032	72,433	33	13,002	1,388	438,608	1,354	335,792	862,600
1950	71	2,485	72,735	65,829	35	14,560	1,138	307,260	1,365	387,660	777,794
1951	220	7,700	131,912	119,387	51	24,684	2,231	771,926	2,527	919,828	1,843,525
1952	128	4,480	127,446	115,345	73	35,332	2,230	718,060	2,734	907,688	1,780,905
1953	95	3,325	103,908	94,042	18	10,332	1,871	490,202	2,634	605,820	1,203,721
1954	147	5,145	118,621	107,358	11	6,490	2,177	596,498	2,896	625,536	1,341,027
1955	156	5,460	114,392	103,531	5	3,730	2,202	656,196	2,571	632,466	1,401,383
1956	179	6,265	97,181	87,954	6	5,270	1,858	583,396	1,668	457,114	1,139,999
1957	13	455	8,829	7,991	1	181	201	57,515	159	36,958	103,100
1958	----	----	----	----	--	----	----	----	----	----	----
1959	18	630	17,562	15,894	3	1,750	325	74,865	362	83,214	176,353
1960	84	2,940	81,593	73,846	10	6,388	1,377	322,183	961	248,041	653,398
1961	63	2,205	49,091	45,384	7	4,290	833	171,444	947	217,695	441,018
1962	46	1,610	31,523	34,202	5	2,895	782	143,952	681	156,722	339,381
1963	25	875	30,112	38,517	5	3,326	542	117,050	484	111,320	271,088
1964	22	770	21,939	28,367	3	2,184	484	126,677	498	135,443	293,441
1965	68	2,380	74,129	95,849	18	12,850	1,457	454,521	1,456	425,137	990,737
1966	68	2,380	54,533	70,511	26	18,664	1,109	335,220	1,147	332,674	759,449
1967	57	1,995	71,387	110,650	20	15,176	1,449	405,804	1,708	472,849	1,006,474
1968	59	2,316	77,129	165,411	18	15,023	1,461	386,028	1,610	434,808	1,003,586
Total	83,045	1,781,702	14,513,288	11,735,029	5,637	1,951,561	83,847	15,228,650	82,717	17,243,559	47,940,501

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furnished the feed for the plant; these tailings had to be upgraded by milling in order to attain the 45–50 percent sulfur necessary for economic operation of the acid plant. After exhaustion of suitable tailings, massive pyrite was mined for the feed, chiefly from the mines of CHC Hill. The total of "ore" for the acid plant amounted to about 297,700 tons of mined pyrite and an estimated 80,000 tons of tailings.

PREVIOUS LITERATURE

Most of the geologic literature on the Rico district was published near the turn of the century when the camp had just finished a period of major silver production and before its potential as a producer of base metals was realized. Papers were published on the ore deposits of Newman Hill by Farish (1892) and on the Enterprise mine by Rickard (1897), both of whom, according to Ransome (1901, p. 308), had been in charge of development at the Enterprise mine at different times. Both of these early papers devote much attention to the geometry of the ore deposits in Newman Hill, including the details of vein structure, the relation between the northeasterly and northwesterly vein systems, and their relation to the bedded or "contact" ore capping the veins at a certain stratigraphic horizon.

The general stratigraphy, structure, and igneous petrology of the whole district was first worked out by Cross and Spencer (1900), who published an excellent geologic map with their report. They described two lithologic phases of the "Devonian," a limestone and a quartzite, and believed that the quartzite underlay the limestone. However, they declined to name Devonian formations in such an area of limited and fragmented outcrops.

Ransome's (1901) report on the ore deposits of the district supplemented the Cross and Spencer report. It gave a very complete account of the mineral deposits, including descriptions of minor prospects as well as the major ore deposits that had been opened to that time. Although his report gave much information on Newman Hill based on original observations, it also relied heavily on the reports of Farish and Rickard for information that was no longer available because of stope caving, particularly in the "contact" ore.

The geologic atlas of the Rico quadrangle by Cross and Ransome (1905) included, as a special economic geology map, the earlier map by Cross and Spencer (1900). In addition to the refinements expected in a finished product, the "Devonian" unit of the earlier publication was divided into two formations, the Ouray Limestone and the Ignacio Quartzite, the latter designated as Cambrian in age. Correlation of the quartzite was by analogy with the geologic section a few miles farther east where geologic work had, in the interim, demonstrated the presence of a Cambrian quartzite.

In 1913, Bastin collected ore specimens from certain mines and mine dumps in Newman Hill for a study of silver enrichment in the San Juan Mountain region. The results were published in 1922. He described the relations of several silver-bearing minerals to other commoner minerals occurring in the specimens and concluded that most of the silver minerals were of hypogene origin.

During World War II, D. J. Varnes spent 2½ months mapping in a part of the Rico district as part of a war program for aiding prospecting in promising base-metal districts. His attention was confined largely to the areas near the town of Rico that are underlain by the Mississippian and Devonian limestones. His preliminary maps with a short explanatory text issued in 1944 have been available to the author in preparing this more complete report on the Rico district.

The Rico district is included in the compendium on the geology and petrology of the San Juan region, authored by Larson and Cross in 1956. Although the information on Rico is all taken from the earlier reports on the district, integration of information on the larger area throws some light on the Rico district in its broader regional setting.

PRESENT INVESTIGATION

The author began fieldwork in the Rico district in the late spring of 1930, and was assisted by Cornelius S. Hurlbut, Jr. At the beginning of the project, B. S. Butler spent several days with the field party, visiting several of the mines and outlining the goals of the project. Fieldwork was discontinued in the fall, but resumed the following summer when Edwin B. Eckel was the assistant. After the 1931 field season, the project was recessed owing to lack of funds during the depression, and the author was assigned to other projects.

World War II, the Korean War, and the assignment of the author to successive projects of higher priority, delayed any further work at Rico until 1955. In the four summers of 1955–58, the fieldwork in the district was completed. This included geologic mapping of the area covered by the mining district topographic map which was prepared by C. A. Ecklund in 1930, and underground mapping of all mines that were accessible during the fieldwork. John G. Stone was the field assistant in 1955; James C. Ratté and David A. Brew, in 1956; James Marlow,

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approximately to a northwest crosscut from the Láura shaft, beyond which the veins lost most of their silver content.

REPLACEMENT DEPOSITS IN RESIDUAL DEBRIS RESULTING FROM SOLUTION OF GYPSUM BED

The rich silver replacement deposits of the so-called "contact" or "Enterprise blanket" in Newman Hill were of a unique type. Although the ores were practically exhausted by 1900 and the workings are no longer accessible, excellent accounts have been published by Farish (1892), Rickard (1897), and Ransome (1901). Only a short summary based on their work will be given here.

The ores were hypogene replacement deposits in the porous debris that was left after the solution of a bed of gypsum near the middle of the lower Hermosa. Part of the debris was slump breccia from the immediately overlying strata consisting of shales and, locally, thin-bedded sandstones, but most of the ore was in a residual silt consisting predominantly of fine granular dolomite and celestite at the base of the dissolved gypsum. Although commonly described as blanket deposits, the contact deposits had linear dimensions defined by the positions of the underlying veins. Thus, a typical contact deposit was a ribbonlike body a few inches to 6 feet thick, as much as 40 feet wide centered on the apex of an underlying vein, and several hundred feet long following the strike of the vein. In shape, it was more comparable to the runs that characterize the Tri-State ore deposits, or to the more linear mantos of western replacement ores. Surprisingly, the contact deposits capped the northwest-trending barren veins as well as the northeast-trending productive ones, and were equally as rich, or even richer, over the barren veins. This fact tends to confirm Ransome's (1901, p. 271–272) surmise that the breaks of the northwest-trending fissure system were as early as those of the northeast-trending system. In mineralogic composition the contact ores were similar to the northeast-trending veins, though the proportions were somewhat different. They were the richest ores known in the district, a representative analysis running 221.5 ounces silver and 0.87 ounce gold per ton of ore.

The contact zone was immediately overlain by fissile black shale which was generally impervious to descending ground waters and thus protected both the contact ores and underlying vein ores from oxidation. The shale held the further practical advantage in that it kept the mine workings relatively dry.

PREVALENCE OF CARBON DIOXIDE

Carbon dioxide gas bubbles up from several natural springs along the valley floor of the Dolores River at Rico and is also commonly found in the mine workings of the district. Any unventilated winze or sump is likely to accumulate this heavy gas to the exclusion of normal air. Evidently, the carbon dioxide comes out of cracks in the bedrock and flows like an invisible liquid into low places, failing to mix with air because of its weight and laminar flow with a minimum of turbulence. The upper surface of the gas in stagnant workings is a horizontal plane of remarkable sharpness. The gas filles a depression to the lip and then flows out in a stream only a few inches thick along the floors of connecting drifts and adits. If entryways are undisturbed, the carbon dioxide may remain sharply segregated on the floor and become a death trap to any bird that tarries too long at the floor of the portal. The natural springs along the edge of the valley floor west of the river at Rico are particularly enticing to small birds, which fall victim to the invisible layer of carbon dioxide that flows out of the orifice, just above the trickle of water that has attracted them to drink or bathe. Carbon dioxide in abandoned mine workings is equally dangerous to humans who explore with electric lamps. The carbide lamp, because of its delicate response to varying degrees of oxygen deficiency, provides a large measure of safety.

Pelleyre diamond-drill hole 1, drilled in 1939 at a very steep angle from a point 1,940 feet inside the Lexington tunnel in Newman Hill, struck a heavy flow of carbon dioxide gas at 798 feet. This flow was at 86 feet below the base of the thick Newman Hill porphyry sill, and was believed to be from the lower part of the Hermosa Formation. The blast was strong enough to blow water back out of the hole. After some difficulty the hole was deepened, and it had penetrated 20 feet into the Uncompahgre Quartzite at 1,119 feet when more gas was found than the ventilating fan could dispose of safely. The hole was abandoned at this depth.

MINES

In the following pages, only those mines are discussed that have been accessible during the fieldwork on which the present report is based. In general, only mines that were worked during or since the 1920's are included, but not all of these have been accessible. An omission that is particularly regrettable because it represents a type of deposit not fully covered otherwise is the Van Winkle mine, worked through a shaft during World War II. How-

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ever, workings from the Atlantic Cable shaft, which exploited a similar type of deposit, were partly accessible to D. J. Varnes in 1943 (1944), and an abstract of his report is here included.

The rich silver mines of Newman Hill were largely exhausted by the time of Ransome's (1901) report, which gives full and adequate treatment of their geology. Many other mine workings throughout the district are also described fully in that report. No attempt is made in the present report to summarize the early history or to repeat the descriptions of abandoned mines, even in areas of current mining operations. The reader is referred to the Ransome (1901) report for the early details.

MOUNTAIN SPRING-WELLINGTON GROUP

The Mountain Spring and Wellington tunnels are on the slope of CHC Hill, on the east side of the Dolores River about 1.5 miles north of Rico. The tunnels enter the hill in a general east-northeast direction; their portals are at altitudes of 9,433 and 9,725 feet, respectively. The Wellington portal is slightly south of the Mountain Spring adit line (pl. 2*C*), and the Wellington adit follows a more easterly course so that the two tunnels do not cross until the general neighborhood of mineralized ground at the Blackhawk fault is reached.

The Mountain Spring tunnel is cut in lower Hermosa strata until the Blackhawk fault is crossed, 2,120 feet from the portal. The fault here has a displacement of about 250 feet, down on the northeast. A short distance beyond the fault, the level workings explore the A bed, at the base of the middle Hermosa (pl. 2*C*). Higher beds in the middle Hermosa between the Mountain Spring and Wellington levels were developed on the downthrown side in the vicinity of the fault, and much zinc-lead-silver ore was taken out. Producing units ranged from the C to I bed; the most productive were D, E, and I. One stope in the upper part of E bed was 230 feet long, as much as 75 feet wide, and a maximum of 9 feet high. The "old zinc stope" in the I bed was 450 feet long, as much as 60 feet wide, and 9 feet high. These ore bodies were at the outer northeast edges of pyrite masses that completely replaced the respective limestone beds outward from the Blackhawk fault. Although the fault was generally avoided in the intertunnel workings, projections from the two main tunnel levels indicate that the zinc-lead bodies were parallel or subparallel to the fault and within 150–200 feet of it. As the mineralization was not coextensive in the different stratigraphic units, the different stopes are not generally superposed or regularly offset from each other. However, the main stopes in the D and E beds show considerable overlap.

The stopes and development workings between them reveal numerous irregularly spaced small faults striking nearly parallel to the Blackhawk fault and showing displacements of 1–5 feet, generally down on the southwest side. One fault in this system, however, shows a larger displacement, amounting to about 70 feet. On the Mountain Spring level, this fault, the Mountain Spring, branches from the Blackhawk fault near the main adit crossing and diverges northward at an acute angle into the hanging wall of the Blackhawk fault (pl. 2*C*). As it dips 50°–82° in the opposite direction from the Blackhawk, it passes over the large stopes in the D and E beds, which are southeast of the Mountain Spring adit, and passes under the "old zinc stope" in the I bed, which is mostly northwest of this adit.

Southeast of the zinc-lead(-silver) stopes, on the approach to the Princeton fault, the A bed in the hanging wall of the Blackhawk fault was mineralized by massive pyrite containing enough copper in places to be minable. The stoped ground is about 50 feet above the southeast drift of the Mountain Spring level.

Old mine maps of the Wellington mine show extensive stopes also in the footwall of the Blackhawk fault. These stopes were inaccesible by 1930, and the mine maps are incomplete, lacking altitudes among other things; hence, details of the geology are lacking. One large stope above the Wellington level is parallel to and within 200 feet of the fault. A much larger stope, or series of stopes, is parallel to the fault where this stoped zone crosses the two main prongs of the Wellington tunnel about 550 feet from the fault, but swings at the southeast end to within 200 feet of the fault. The northwest end is open and is reported to connect with old stopes in the Logan mine. Between the two prongs of the Wellington tunnel, the existing mine map shows the stope to be 40 feet below the Wellington level. Mapping on this level and in a winze that was accessible in 1931 indicates that the ore in this block of ground was in the A bed. Exposed on the level are several closely adjacent faults of small displacement (14 to perhaps 20 ft), all in a system parallel to the Blackhawk fault dipping northeast or vertically (pl. 2*C*), and these faults must cut the stoped ground below the level. The swing in stope plan at the southeast end is doubtless explained by a small transcurrent fault that was formerly exposed in workings on the Wellington level near the point where the change in direction takes place. Presumably, the stopes in this old ground were largely in zinc-lead (-silver) ore.

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Since the early 1930's, the main tunnels of the Mountain Spring and Wellington mines have pushed well beyond the Blackhawk fault. Another fault of nearly parallel strike, but having opposite displacement down on the southwest of a few tens of feet, was crossed on the Mountain Spring level about 500 feet beyond the Blackhawk fault, at 20,110N, 17,150E, (pl. 2*C*). This fault shows no mineralization in the A bed on this level nor in the E bed on the Wellington level, but raises that extend from a caved drift in its footwall on the Mountain Spring level suggest some mineralization between the two levels. About 70 feet of the fault vein, showing a maximum thickness of 2 feet, was stoped for its zinc-lead content in the arkose below the A bed.

About 500 feet farther at 20,225N, 17,620E (pl. 2*C*), the Mountain Spring tunnel crosses, in strata about 90 feet below the A bed, a small fault along which most of the limestones of the middle Hermosa were richly mineralized. This fault is also virtually parallel to the Blackhawk fault, occurring 900 feet northeast of it on the Mountain Spring level as measured perpendicular to the fault strike. It dips irregularly (55°–90°) toward the Blackhawk fault and drops the strata on that side. The displacement is about 15 feet on the A bed level, but it decreases to 6–8 feet on the E bed level, and possibly to less at higher levels, though the fault is still a conspicuous break on the J bed level. Transverse breaks of a comparable displacement are not mineralized. The strata dip gently in a northerly direction. Zonal placement of the zinc-lead ore bodies on the border between unaltered limestone and a comparatively barren pyritic core centered on the fault is conspicuous on the A, D, and E (Wellington) levels; it is less so on the C level because the pyritic core was well, though irregularly, mineralized by sphalerite and galena. The H level shows a partial barren core, but here, also, considerable ore has been found in the pyrite. On the I, J, and K levels, which are not so extensive as most of the lower ones, the ore was mined from runs on the southwest side of a pyritic body centered on the fault, but no ore was mined from the opposite side of the pyrite on the upthrown side of the fault. The Princeton fault bounds the southeast edges of the stopes on the D, E, I, and J levels and must be very close to the stope edges on the C and H levels. On the L bed level, surficial weathering beneath the thick landslide mass of CHC Hill, augmented by proximity to the Princeton fault, has converted much of the ore-bed limestone to a red clay.

PIGEON TUNNEL

The Pigeon portal is 1,800 feet north of the Mountain Spring portal at an altitude of 9,320 feet. The tunnel enters the hill at the base of the large outcrop island in the landslide area of CHC Hill, on the footwall side of the Blackhawk fault. Where the fault is crossed, 660 feet from the portal (pl. 2*C*), the fault vein is about 40 feet thick. Immediately after crossing the fault, the tunnel swings right at an obtuse angle and stays in the hanging wall close to the fault, following an irregularly meandering course for about 1,200 feet. Near the middle of this stretch, the tunnel swings across the fault for a short distance, and then back, though a crosscut probes the footwall an additional 65 feet. The fault vein is here only 3 feet thick. At the breast of the Pigon tunnel the Pigeon raise connects through to the Mountain Spring level.

The A bed is exposed on the surface just south of the Pigeon portal, and appears in the roof of the tunnel, 120 feet in, but for the most part the tunnel crosscuts in sandstones and shales of the lower Hermosa until the Blackhawk fault is reached. After penetrating the fault vein and turning into the hanging wall of the fault, the tunnel traverses 110 feet from this turn to the point where the H bed limestone first appears above the floor, dipping 12° WNW. The I bed is present at the top of a 97-foot raise at the turn, which is only 15 feet from the edge of the Blackhawk vein at tunnel level. The structure farther back in the tunnel is complicated by numerous small faults and changes of dip, and the H bed appears again in the neighborhood of the crosscut into the footwall. No other limestone beds are exposed in the workings. Mineralization has been minimal at tunnel level, and there are few indications of ore derived from other levels; but small stopes off the Pigeon raise to the Mountain Spring level contained some tetrahedrite in the ore.

ST. LOUIS TUNNEL

The St. Louis tunnel was driven by the St. Louis Smelting & Refining Co. during 1930–31 to explore for deep ore horizons below CHC Hill. The portal is at an altitude of 8,844 feet, on the east bank of the Dolores River, 1 mile upstream from Rico. The tunnel runs N. 70°33′ E. for a distance of 5,160 feet. At 4,531 feet the Blackhawk fault vein was crossed, and 50–65 feet beyond it, long crosscuts were turned in both directions in the hanging wall of the fault (pl. 2*C*).

The crosscut to the northwest runs 2,920 feet, though by the year 1955 it had caved at 1,445 feet at the Mountain Spring raise to the Mountain Spring

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level. The end stretch of this crosscut crossed from the northeast to the southwest side of the Pigeon tunnel near its breast, though a few hundred feet below the Pigeon tunnel. The crosscut stayed within 140 feet of the projected position of the Blackhawk fault as far as the Mountain Spring raise and is believed to have crossed into the footwall of the fault at 1,900 feet (St. Louis Smelting & Refining Co., unpub. map).

The crosscut to the southeast was driven only a short distance beyond the Princeton fault by the St. Louis Smelting & Refining Co., but was extended in the 1950's by the Rico Argentine Mining Co. to their workings on Silver Creek. It crosses the Princeton fault at 403 feet from the St. Louis tunnel. At 1,450 feet it crosses the Blackhawk fault at an acute angle and continues in the footwall of this fault to a point 390 feet northwest of the Argentine shaft where it crosses back into the hanging wall (pl. 3*G*). The total distance along the drift from the St. Louis tunnel to the Argentine shaft (as projected) is about 4,450 feet. The crosscut shows only minor deviations from a straight line and is believed to be within 110 feet of the Blackhawk fault throughout its length.

The strata traversed by the St. Louis tunnel from its portal are lower Hermosa sandstones and shales that dip gently to the south-southwest. The tendency for lower strata to rise into the tunnel as it penetrates in an east-northeast direction into the hill is offset by a series of small- to moderate-sized transcurrent faults that repeatedly drop the strata on the breastward side by approximately the amount of structural rise. Hence, only a limited stratigraphic section is exposed, apparently below the middle of the lower Hermosa. A sill of the hornblende latite porphyry is intercalated in the strata, its base dropping slightly in the section to the northeastward in a series of small steps. Thickness of this sill is hard to estimate, considering the low dip and irregularities in boundaries; but a rough calculation at one place suggests about 80 feet, and it may locally exceed 100 feet, though the last exposures to the northeast in the tunnel before disappearance into the roof suggest a thinning in that direction. About 195 feet before the Blackhawk fault is reached, the tunnel crosses an irregular dike of alaskite porphyry 25 feet thick, which dips nearly vertically (pl. 2*C*).

The Blackhawk fault has a displacement of about 200 feet where the St. Louis tunnel crosses it. The strata in the hanging wall are somewhat higher in the lower Hermosa, and include, in addition to the dominant sandstone and shale, a little shaly limestone and a 15-foot bed of dolomite. Along the line of the tunnel, the strata, which have changed to a gentle northeasterly dip here, are broken by at least nine moderately sized faults of undertermined throw, which strike parallel to the Blackhawk fault but dip in the opposite direction. These faults doubtless have normal displacement, and thus they offset the effect of the stratigraphic dip just as do the faults in the front part of the tunnel, but in the reverse direction.

The long crosscut southeast to the Rico Argentine mine crosses the Princeton fault into dominantly greenish sandstones and arkoses and some shales, dipping 25° NW. but flattening within a few hundred feet, and believed to belong to the Rico Formation. Farther southeast, just before the Blackhawk fault is reached, a 30-foot dike of alaskite porphyry occurring in the immediate hanging wall of this fault may be a southeastward continuation of the previously mentioned dike. In the footwall of the fault, the crosscut enters northwest- to northward-dipping upper Hermosa strata that are about 640 feet above the base of this division. These strata are, of course, in the hanging wall of the Princeton fault. The rest of the crosscut traverses downward through the upper Hermosa section, reaching the top of the middle Hermosa in ground that is part of the Rico Argentine mine.

The exploration of the Leadville-Ouray Limestones for which the St. Louis tunnel was initially planned was unsuccessful. Although a little ore was taken here and there from pyritic beds in the lower Hermosa that were intersected in the extensive tunneling on the hanging-wall side of the Blackhawk fault, the lower Hermosa proved to be thicker under CHC Hill than anticipated, and diamond drilling in depth in the vicinity of the fault failed to reach the limestones of the Mississippian and Devonian. Drill hole 1 that was put down vertically from a station 120 feet in the footwall (portalward) of the Blackhawk fault (pl. 2*C*) went 430 feet in sandstone, shale, pyrite, and "porphyry." The last is evidently a 120-foot sill in the lower Hermosa, intersected at depths of 126–246 feet. The pyrite, intersected at several levels in thicknesses of as much as 18 feet of varying proportions of pyrite, may, in part, represent replaced limestone or dolomite beds in the lower Hermosa, though some of the zones containing only 15–25 percent pyrite are indicated as in sandstone or shale. Drill hole 3 that was put down vertically from a station 310 feet in the hanging wall of the fault penetrated 761 feet of sandstone, shale, porphyry, and some limestone and gypsum;

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the gypsum was below 600 feet. The porphyry here is at two levels, a 112-foot intercept at 184–296 feet and another 112-foot intercept at 630–742 feet, the later, however, containing a 9-foot sandstone parting.

If the two porphyry intercepts in hole 3 represent sills, the upper could well be the one that shows on the other side of the Blackhawk fault in the St. Louis tunnel, rising and disappearing into the roof as the fault is approached from the southwest. The interesting possibility is also raised that this upper sill could be the same as the one intersected at 126–246 feet in hole 1 on the other side of the fault. If so, the major structural displacement on the Blackhawk fault zone here comes not on the quartz vein that almost universally marks the fault, but on the alaskite porphyry dike that, along the line of the tunnel, lies 195 feet in the footwall of the quartz vein and 80 feet portalward from drill hole 1. Intrusion of the alaskite is believed to be late in the geologic history of the district, and most of the displacement on the Blackhawk fault may have preceded it. Evidence tending to support the surmise that the displacement occurs on the dike is the failure of drill hole 2 to intersect the porphyry above the tunnel level. This hole was put up 90 feet at an angle of 61° (as projected) in the same block as hole 1, between the alaskite porphyry dike and the Blackhawk fault (pl. 2*C*).

The lower porphyry intercepted in hole 3, if a sill, might well be the attenuated extension of the Newman Hill sill, for a rough calculation, taking into account the thickness of lower Hermosa indicated in Newman Hill, suggests that about 250 feet of lower Hermosa strata should lie below the lower sill.

RICO ARGENTINE GROUP

The workings that constitute the Rico Argentine group of mines are on Silver Creek, about 1.5 miles northeast of Rico. Most of the surface openings are on the southeast side of the creek, but two shafts are on the northwest bank—the Argentine shaft and the 517 shaft which was raised in 1961–64 from St. Louis level to intersect a short entry tunnel from the surface. The main openings on the southeast side of the creek are tunnels and include, from the creek upward, the James G. Blaine tunnel, which is practically at creek level, the Rico Consolidated middle and upper tunnels, the Argentine tunnel, and the Log Cabin (Blackhawk) tunnel. The Rico Consolidated tunnels are caved at the portal but were accessible in the 1950's through extensions from the Argentine tunnel. Several tunnels higher than the Log Cabin have been long caved at their portals, though the Smith tunnel was accessible in 1957 through the Log Cabin workings.

Most of the ore taken from the Rico Argentine workings in recent years has come from levels below the Blaine tunnel. These are at irregular intervals, 67–140 feet, from the 200 to 600 levels, and undoubtedly lower levels will be established with further development. Although the Argentine shaft goes to the 300 level, it has been unusable for many years. The ore at an intermediate stage was taken out through an interior shaft (No. 3) from the Blaine level, or through the long St. Louis tunnel crosscut which comes in on the 500 level. As the St. Louis tunnel exit required an underground haul of 9,000 feet, and a surface haul of about the same to bring it back to the mill near where it was mined, the company drove the new shaft on the northwest side of the creek. The St. Louis crosscut serves a very useful purpose in providing gravity drainage for all workings on, or above, the 500 level.

The numerous workings of the mine group exploit the sulfide replacement deposits in the limestones of the middle Hermosa and in two of the lower limestone beds of the upper Hermosa in the vicinity of the Blackhawk fault. Both sides of the fault have been mineralized, but, as much of the favorable ground on the footwall side has been eroded, most of the workings to date have been in the hanging wall. All the limestone units of the middle Hermosa have been cut at some place or other, though some of the beds, in particular the A and B beds, have not as yet been productive. Except for local deviations in the vicinity of faults, the strata dip northeast at angles of 30°–60°, averaging perhaps 40°. Mining has been complicated by numerous faults, some of which are regular enough to be projected between levels, whereas others are of local significance.

The structural features that localize the stopes are generally obscure. Where the ore follows very closely the intersection of the limestone bed with the Blackhawk fault, the shattering adjacent to the fault was obviously responsible. However, some of the ore bodies extend 200–300 feet from the fault. The stopes commonly run diagonally down the dip of the bedding. In some places, bedding slip faults can be identified along, or just above, the ore bed, and the attendant shattering in the limestone was doubtless the determinant. In other places, faults of small displacement can be recognized in the roofs of stopes, and such faults broke the susceptible host rock and acted as feeders for the ore solutions.

LOG CABIN (BLACKHAWK) TUNNEL

The Log Cabin tunnel enters the hill at about

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altitude 9,742 feet and bears generally east-southeast, nearly parallel to the strikes of the Blackhawk fault and of the strata. Its portal is 25 feet within the hanging wall of the Blackhawk fault just southeast of the Last Chance fault junction, and the entry tunnel merges onto the fault 250 feet from the portal. The mineralized ground is in the hanging wall to the northeast. At 340 feet from the portal, the main tunnel crosscuts over to the northeast to follow the Alleghany fissure, which is parallel to and about 200 feet from the Blackhawk fault; but farther along the tunnel, a branch crosscuts back to the Blackhawk fault and drifts along a small break in its immediate hanging wall (pl. 3*A*). Maximum penetration of the Log Cabin tunnel is about 1,400 feet into the hill.

The limestone beds mineralized include the H, I–J, K, and L beds at the top of the middle Hermosa. The distribution of the beds at the Log Cabin level is shown on plate 3*A*. Most of the stopes at and above the Log Cabin level are between the Alleghany and Blackhawk breaks and within 210 feet of the latter, but those on the H and I–J beds follow eastward diagonally down the bedding to the Argentine level. As the Blackhawk fault also dips in this direction, though at a steeper angle, the distance between the fault and the outer edges of mineralized ground does not greatly increase. In a part of the ground, the stopes in the four ore beds are roughly superposed, indicating a common feeder system among the cross fractures. No single fracture can be mapped to account for this, but a system of connecting fissures are present. The ore solutions were thus able to travel from one to the other in a general zone of fracturing. The stope in the H bed, extending from below the Argentine level at the bottom to above the Log Cabin level at the top, is 420 feet long and a maximum of 60 feet wide, as projected on a horizontal plane. The stope in the I–J bed bottoms at the Argentine level and extends up through the Log Cabin level to somewhat above the Carbonate tunnel whose caved portal is 109 feet above the Log Cabin portal. This stope (as projected) is 580 feet long and a maximum of 150 feet wide, though averaging 60–80 feet. The stope in the K bed, which is thin, bottoms between the Argentine and Log Cabin levels and extends through the Log Cabin level to some distance above the Smith tunnel, breaking through to the surface at its upper end. It has a projected length of 500 feet and a width that is generally less than 40 feet, but attains 90 feet at the upper end. A persistent bedding fault at the top of the K bed may have furnished the structural setting for the mineralization. In the L bed, part of the stoping is superposed on that in the lower beds, but there is extensive stoping which is independent of that in lower beds. None of the stopes in the L bed extend below the Log Cabin level. The largest stope, superposed at the west end and running more nearly parallel to the strike of the bedding, is 580 feet long and maximum 120 feet wide.

The Alleghany fissure, so conspicuous on the map of the Log Cabin level (pl. 3*A*), may have been a mineralizing fissure for all the traversed beds (H to L) adjacent to its northwest extent along the level, but it failed to mineralize the L bed for a long stretch near the southeast end of the level. The fissure is a fault of reverse throw and small displacement. It dips mostly southwest at 60°–80°, with the southwest side up 5–18 feet as measured on the level. The fissure contains 2–8 inches of gouge, pyrite, calcite, and, locally, some sphalerite.

BLACKSMITH TUNNEL

Although the Blacksmith tunnel has not been accessible during the fieldwork for the present report, it is of special interest because of the stratigraphic units involved in the mineralization. The tunnel portal is S. 56° E., 530 feet from the Log Cabin portal, and about 267 feet higher. As interpreted from cross section and stope maps prepared by W. R. Landwehr, geologist of the American Smelting & Refining Co., the tunnel provided access to stopes in the two lowest limestone beds of the upper Hermosa within 200 feet of the Blackhawk fault. The stratigraphic units mineralized are Nos. 27 and 29 of the composite section (see p. 24), whose bases are about 126 and 202 feet, respectively, above the base of the upper Hermosa. The lower stope trends nearly parallel to the strike of the bedding and is 185 feet long and 40 feet wide maximum. The upper one, which is really two closely juxtaposed stopes of very irregular outline, shows an overall projected length of nearly 200 feet down the dip of the bedding starting from the Blackhawk fault and a maximum width of 120 feet. These stopes are not superposed, nor do they overlie stopes in limestones of the middle Hermosa. Lower limestone strata at the top of the middle Hermosa are pinched out against the fault below the level of the Blacksmith tunnel.

ARGENTINE TUNNEL

The Argentine tunnel is in the hanging-wall block of the Blackhawk fault northeast of the Log Cabin tunnel and about 160 feet lower, its portal having an altitude of about 9,588 feet. It trends in a general southeasterly direction nearly parallel to the strike of the bedding and shows an overall penetration of

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about 2,400 feet into the hill. In the first 930 feet are several prongs that are more or less interconnecting, but beyond that, the working is a linear tunnel from which a few crosscuts have been extended (pl. 3*B*).

Some of the prongs of the tunnel in the first 930 feet intersect the lower ends of two of the large stopes previously discussed for the Log Cabin level, namely, those in the H and I–J beds. At their lower ends the outer edges of these stopes are, respectively, 160 and 220 feet from the Blackhawk fault, as measured on the level. Much of the ore from stoping in the K bed between the Argentine and Log Cabin levels was also taken out through these prongs of the tunnel. The Argentine workings in this block also intersect mineralized ground in a lower bed, the E bed, which pinches out against the Blackhawk fault well below the Log Cabin level. The stoped ground in the E bed is small and is characterized by an abundance of garnet. Plate 3*B* shows the distribution of the limestone beds on the Argentine level.

The Blackhawk fault has been probed by crosscuts at four places (pl. 3*B*), but no workings penetrate more than 40 feet into the lower Hermosa strata of the footwall.

The other dominant structure revealed on the tunnel level is the Honduras fault, which is a reverse fault trending slightly south of east and dropping the strata on the north side about 140 feet. Although the displacement is in the same direction as that of the Blackhawk fault, the dip is in the opposite direction, mostly 70°–80° S. The fault break is occupied by 2–8 feet but commonly about 5 feet of gouge, quartz, and pyrite. The I–J bed limestone unit in the dropped block has been mineralized and stoped at a level between the Argentine and underlying Blaine level. This "4 bed" stope,[7] though irregular in shape, is about 250 feet long in a direction nearly perpendicular to the fault and 90 feet wide at the maximum. However, another prong of the stope 10–20 feet wide follows along the north side of the fault for a distance of 140 feet west from the main stope. Mineralization of this latter prong can be attributed to shattering along the hanging-wall side of the Honduras fault. The main northward-trending prong lies along the northwest side of the Rico Argentine dike; shattering of the limestone adjacent to the dike probably furnished the channelways for introduction of the ore solutions. However, the northern part of the stope is also traversed by a small fault dipping westward at 45°–60° and dropping the strata on the west about 15 feet. Updip and a little farther north this fault was responsible for a replacement blanket of sulfide ore at a higher stratigraphic level in the middle tunnel of the Rico Consolidated mine (see p. 84). The remote end of the "4 bed" stope is about 450 feet from the Blackhawk fault. The stope is of mineralogic interest in that cosalite and huebnerite, rare minerals for the district, are present in the massive pyritic replacement ore.

In the ground explored by the deeper parts of the Argentine tunnel, mineralization was not so extensive as in the first 930 feet. The deeper part of the tunnel follows the general course of the Alleghany fissure. Over much of the Argentine level this fissure is 60–120 feet northeast of the Blackhawk fault, striking nearly parallel to it but dipping generally in the opposite direction (southwest) at 60°–80°, except near the southeast end of the mine where it steepens through verticality and farther southeast dips parallel to the Blackhawk fault. Displacement on this level amounts to a few tens of feet, down on the northeast. Although the northwest end of the Alleghany fissure was apparently an important part of the feeder system for the mineralization in the front part of the mine, it was a less effective mineralizer farther southeast. Nevertheless, there are some stopes that are obviously related to it. Where it intersects the I–J bed above the Argentine level in the 3-compartment raise to the Log Cabin level, at 14,060N, 14,690E (pl. 3*B*), a stope extends southeast for at least 180 feet. The stope is about 10 feet wide, and narrowly confined to the intersection of the fissure with the ore bed which here strikes nearly parallel to the fissure and dips about 45° NE. This stope is about 150 feet from the Blackhawk fault.

At 250 feet from the southeast end of the tunnel where the Alleghany fissure dips northeast, its hanging wall contains the 138 stope which is a pyritic copper stope in the L bed, running eastward diagonally down the dip of the bedding to the Blaine level. Owing to the gradual convergence of the Alleghany fissure and Blackhawk fault at this end of the mine, the 138 stope is also only a short distance in the hanging wall of the Blackhawk fault, 60 feet from the fault at the Argentine level and 120 feet from the fault at the Blaine level. The stope is 300 feet long as projected on a horizontal plane and a maximum of 70 feet wide. Slickensides in the stope indicate that faulting along the bedding was an important structural preliminary to the mineralization. The stope is reported to have yielded 2 ounces of silver for each percent of copper.

[7] The stope is labeled "4 bed" stope on mining company maps, but this is a misidentification, as it is really in the 2 bed of company terminology; see the composite section, p. 24.

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A crosscut to the northeast near the end of the Argentine tunnel intersects a bedding fault near and at the top of the L bed. There has been some stoping of this bed on and below the fault and updip from the level, but the amount of ore obtained was not great. The mineralized segment of the ore bed is bounded laterally by crosscutting porphyry dikes, one of which was offset by the bedding fault. Stoped ground in this block is a maximum of 250 feet from the Blackhawk fault.

RICO CONSOLIDATED TUNNELS

The three tunnels of the Rico Consolidated mine are about 400 feet northeast of the Argentine portal. The altitude of the upper tunnel portal is 9,629 feet, and of the middle portal, about 9,563 feet. Both portals are caved; but the middle tunnel is accessible from the Argentine workings, and the upper tunnel is accessible from the middle tunnel. The lower tunnel is caved.

The tunnels enter the hill in an irregular, but generally, south-southeasterly direction. The middle tunnel at about 600 feet from the portal hits the Honduras fault and drifts east on it for 250 feet (pl. 3*B*). The strata traversed are chiefly the basal part of the upper Hermosa. However, the L bed, at the top of the middle Hermosa, is intersected 80 feet before the Honduras fault is reached and is also cut on the south side of the Honduras fault in the drift to the east. It is not mineralized.

The only mineralized ground is in the front part of the mine, in the lowest good limestone bed of the upper Hermosa, unit 27 of the composite section (see p. 24). Most of the mineralization is adjacent to the 210 Drift fault near its northeast end, and chiefly on its south or upthrown side. In contrast to its general vertical attitude elsewhere, the fault here dips 70° S., and hence shows reverse displacement amounting to about 20 feet. A large stope 20–30 feet wide plunges eastward diagonally down the dip of the bed at its intersection with the fault, and a pyritized blanket of the ore bed about 100 feet wide extends south from the fault diagonally up the bedding dip and nearly perpendicular to the fault. This pyrite blanket is traversed lengthwise by the small cross fault, dipping 46°–60° W., that is followed for several hundred feet by the main tunnel. The fault drops the strata on the west about 17 feet and also displaces the Rico Argentine dike (pl. 3*B*). It is undoubtedly the feeder for the sulfide mineralization in the pyritic blanket. The center of this blanket is too low grade to be minable, but ore stopes were developed along its two sides. The larger stope on the east side is about 160 feet long as projected on a horizontal plane and is 15–20 feet wide. A bedding fault at the top of the ore bed doubtless facilitated the introduction of the ore solutions. The presence of hydrated iron oxides and green copper stains in the walls of the stopes suggests that the ore taken out was partly oxidized.

An additional small stope was opened along the northwest side of the Rico Argentine porphyry dike. This stope was not completely mapped, so its length is not available. It has a maximum width of 20 feet but is for the most part only 6 or 7 feet wide.

The upper tunnel explores the ore bed at a higher level where it is massively pyritized, but there was only negligible stoping on this level, along the edge of the porphyry dike. The tunnel crosses the vertical Honduras fault at 590 feet from its portal and extends 155 feet farther into the footwall.

The stopes on the middle tunnel level are 600–800 feet from the Blackhawk fault and 260–460 feet from the Honduras fault. It appears obvious that the 210 Drift fault, which in most places is a tight poorly mineralized fissure, has acted as a mineralizing channel in this place, though the eventual trunk channel may well have been the Blackhawk fault.

JAMES G. BLAINE TUNNEL

The Blaine tunnel enters the southeast bank of Silver Creek just above creek level at an altitude of about 9,336 feet, 400 feet east of the Rico Argentine mill. It starts on the southwest side of the Blackhawk fault in the thick shale unit just above the H bed of the middle Hermosa and follows a general east-southeast course until it intersects the Blackhawk fault, 410 feet from the portal. From here, the course is southeast along the Blackhawk fault, though the fault is not followed in detail (pl. 3*C*). In the first 1,700 feet from the portal there is, in addition to the main haulage tunnel, an intricate system of drifts, crosscuts, and stopes that develop the blocks of ground on both sides of the fault, but particularly the northeast, or hanging-wall, side. Beyond 1,700 feet from the portal (measured in a straight line), the chief working is the main haulage tunnel, but numerous tributary crosscuts explore adjacent ground. The total straight-line length of the tunnel is 3,750 feet, though the actual length is somewhat greater because of deviations in course. In the last 1,250 feet, the main tunnel diverges from the Blackhawk fault into its hanging wall, though crosscuts to the fault indicate that the tunnel is nowhere more than 125 feet northeast from the fault.

The structure in the front 1,700 feet of the Blaine workings is greatly complicated by the junction of the Honduras and Blackhawk faults on this level. Although both faults drop the strata on the north

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side, the Honduras is a reverse fault that dips opposite to, and merges with, the Blackhawk in depth. On the Argentine level where the two are somewhat farther apart, they are slightly divergent in strike, and the Honduras fault is a well-defined break of uniform trend. On the Blaine level, however, where the faults are closer together, each fault has apparently affected the course of the other and the two average nearly parallel in strike from their junction to as far east as the Honduras is exposed on the level. Thus, the two faults at 800 feet east of their junction are only 210–220 feet apart (pl. 3*C*). Furthermore, the Honduras fault has broken into several segments, some of which show curving trends and southward dips as low as 40°. The block between the two faults is further broken by other small faults and by porphyry dikes and sills that add to the complication. Correlation of the beds are correspondingly uncertain, as indicated by the queries on plate 3*C*.

The stope ("4 bed" stope) above the Blaine level in the I–J bed on the northwest side of the Rico Argentine dike and north of the Honduras fault was mentioned in the discussion of the Argentine tunnel. Most of this ore was taken out through the Blaine tunnel. A stope similar in position but narrower ("upper Con" and "lower Con" stope) was developed in the H bed on the southeast side of the dike, running on an incline nearly parallel to the dip of the bedding from above the Blaine level to below the 200 level. Some faulting shows along the dike wall. This stope is generally 5–20 feet, though locally 50 feet, wide and more than 300 feet long as projected on a horizontal plane. Its height of 40–60 feet in places suggests that some of the clastic strata above the H bed may have been shattered and mineralized. It connects at the bottom with another stope that extends to the 300 level. At its upper end it is close to the Honduras fault, though the breakup of the fault into several segments here makes the exact position of the fault indefinite. The upper end of the stope is about 200 feet from the Blackhawk fault.

Several stopes in the narrow block of ground between the Honduras and Blackhawk faults were only partly accessible during the fieldwork for the present report. They were developed in the C, D, E, and H beds and are only in part superposed. Although these stopes do not extend up to the Argentine level, they are in the same general block of ground that contains the major stopes of that level, indicating that the hanging wall of the Blackhawk fault near its junction with the Honduras fault was a major locus for ore deposition.

The back part of the Blaine level beyond 1,700 feet from the portal does not contain ore stopes commensurate to the amount of development work done in exploration. Perhaps this is due in part to the abundance of porphyry, a generally unfavorable host rock for ore, in thick dikes and sills in the most favorable ground adjacent to the Blackhawk fault. The Alleghany fissure, which follows the Argentine level overlying this stretch of the Blaine tunnel, joins the Blackhawk fault above the Blaine level, except at its southeast end where the reversal of dip visible on the Argentine level may have extended a segment of the fissure to the Blaine level (pl. 3*C*). Two other fissures northeast of this possible Alleghany remnant and dipping northeast have mineralized, respectively, the I–J bed on the south side of the main haulage tunnel east of the long crosscut to the south and the K bed in a narrow stope above the haulage level. Both stopes are within 110 feet of the Blackhawk fault but are relatively small. The 138 stope, in the L bed southwest of the tunnel, is a large stope in the hanging wall of the Alleghany fissure, already mentioned in the discussion of the Argentine level.

In the front part of the Blaine tunnel, the hanging wall of the Blackhawk fault northwest of the Honduras fault junction contains several relatively small stopes in the immediate vicinity of the Blackhawk fault. These stopes were worked partly in winzes below the level. South of the 210 Drift fault, they are in the C and D beds; north of this fault, which drops the strata on the north about 265 feet at the Blackhawk fault junction, the only significant stope in the hanging wall is in the Morris Cook inclined winze in the K bed. This stope, which is about 20 feet wide and extends for about 180 feet from the Blackhawk fault diagonally down the dip of the bedding, is just below a porphyry sill whose base may have been somewhat mineralized.

The vein on the Blackhawk fault above the level was stoped between sandstone walls for about 150 feet southeast from where the entry adit first hits the fault.

In contrast to the relations on the Argentine and higher levels, the Blackhawk fault in the front part of the Blaine tunnel has only the moderate displacement that prevails north of the junction with the Last Chance fault—43 feet just north of the 210 Drift fault junction. Hence, the middle Hermosa strata, though somewhat uplifted, have been only partly eroded from the southwest or footwall side of the fault. Several of the limestone beds here contained important ore bodies. The 102 drift traverses a complexly faulted block southwest of the

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Blackhawk fault. At its beginning, it drifts on a conspicuous steeply north-dipping vein which, at first impression, appears to represent the southwestward continuation of the 210 Drift fault of the Blackhawk hanging wall, offset 50 feet to the southeast by that fault. However, the vein is truncated within 160 feet by a lower dipping fault, and other fault veins, mostly dipping north at 43°–60°, are crossed by the 102 drift within a short distance (pl. 3*C*). Furthermore, exposures on the 200 and 300 levels fail to show any fault break on the southwest side of the Blackhawk having a throw comparable to that of the 210 Drift fault. Hence, the concept of a simple earlier fault having considerable throw, crossed and offset by the Blackhawk fault, is untenable. However, there may have been an originally continuous break whose displacement was greatly augmented on the northeast side when the Blackhawk fault was formed. The faults crossed by the 102 drift and its branches are of small displacement, but they produced several ore bodies at their intersections with limestone beds. Because of the complexities produced by the faulting, the ore beds are not all satisfactorily identified, though some ore bodies are definitely in the E bed, and others are probably in the H bed. Most of the stopes are relatively small, and narrowly confined to the faults. Some, not now accessible, may actually be on the veins in clastic strata. At the end of the drift, however, a huge stope was opened in the E bed. Only a small upper part of this stope is above the Blaine level, but it is practically continuous downdip to the 300 level. Most of the ore was removed through the 200 and 300 levels. Between these levels the stope is in contact with the Blackhawk fault, but its upper end is 470 feet from the fault as measured on the Blaine level.

The only other large stope in the footwall of the Blackhawk fault on the Blaine level is north of the entry tunnel from the portal. This stope is in the I–J bed, extending from the intersection of this bed with the fault out to a maximum of 40 feet from the fault in the ground above the Blaine level. The stope follows the dip down to below the 300 level and is much wider at the 200 level.

The footwall of the Blackhawk fault southeast of the junction with the Last Chance fault has been explored by crosscuts at several places. These crosscuts have penetrated lower Hermosa sandstones and shales containing a large proportion of porphyry in dikes and sills. The longest crosscut to the south is 700 feet. The last 500 feet of this is in porphyry that appears to be a thick sill whose upfaulted base is visible a few feet above the floor of the crosscut near and at the end. The sill contains at one place a narrow horse of shale and sandstone which has nearly vertical sides and is traversed by a small fault. This sill may be the underground extension of the Newman Hill sill (see p. 34).

200 LEVEL

The 200 level is 100 feet below the Blaine tunnel level at the No. 3 shaft. It is the highest level below the bed of Silver Creek and was originally opened from the Argentine shaft. Later, the level was worked through the No. 3 shaft whose collar is on the Blaine level, but it is now worked through the 517 shaft driven in the 1960's.

The main haulage tunnel for the level follows the Blackhawk fault fairly closely for about 650 feet from the Argentine shaft southeast to 100 feet beyond the junction with the 210 Drift fault (pl. 3*D*). Here, the tunnel turns more east-southeastward into the hanging wall of the Blackhawk fault and extends 1,500 feet farther in a fairly direct line. Where the tunnel is along the Blackhawk fault, drifts into the footwall explore and develop several ore deposits, and two crosscuts explore barren ground in the hanging wall. Workings tributary to the tunnel after the turn to the east include a major crosscut (214) for 520 feet to the northeast along the Rico Argentine dike, and three exploratory crosscuts to the south, two of which reach the Blackhawk fault.

Distribution of the limestone beds on the 200 level is shown on plate 3*D*. Major ore deposits were stoped in the footwall of the Blackhawk fault, in part from the 200 level. The two largest of these in the E and I–J beds, apexing above the Blaine level and bottoming on or below the 300 level, have been previously mentioned. The stope in the E bed is in contact with the fault between the 300 and 200 levels. Much of the stope in this interval was not accessible for examination; part of it is only 30 feet wide, but locally its outer edge extends to 200 feet from the fault. Above the 200 level the stope extends away from the fault, generally west diagonally up the intersection of the E bed with one or more of the footwall faults mentioned in the discussion of the Blaine level. That part of the stope above the 200 level is somewhat curving, 500 feet long as projected on a horizontal plane, and 20–50 feet wide, though containing some barren blocks that have been left as pillars. A smaller stope in the same block, occurring to the north but connected with the big one at both ends, is developed in the E bed just above a somewhat crosscutting porphyry sill. This stope is 280 feet long, 6–25 feet wide, and 5–15 feet high. At least some of the ore in it was contained in the highly altered porphyry.

Mineralization in the H bed on the footwall side of the Blackhawk fault was limited to a narrow tabular ore body parallel to the fault. The stope is mostly 6–8 feet wide but increases to 27 feet wide at the upper end, which is well below the Blaine level. A stope height of 40 feet indicates that the complete thickness of the bed was mineralized. At the upper end of the stope, a porphyry dike 5–8 feet thick between the Blackhawk fault and the mineralized limestone shows some slickensiding parallel to the fault.

The stope in the I-J bed apexes above the Blaine level and bottoms against the Nellie Bly cross fault below the 300 level. It is a wide blanket stope bordering directly on the Blackhawk fault above the 200 level, but below that level a low-grade or barren pillar intervenes between the stope and fault over much of the stope length. Diagonally down the dip of the bedding the stope shows an overall length of about 560 feet as projected onto a horizontal plane, which is equivalent to a true length of 650 feet; the greatest width is 200 feet, at the 200 level. However, the stope is relatively thin, as the mineralization was confined to the top 5 or 6 feet of the limestone except near the fault above the 200 level where thicknesses to 20 feet are indicated by the configuration of the stope.

A narrow pipelike stope in the K bed borders the footwall side of the Blackhawk fault from the 200 to just below the 300 level, starting very near the Argentine shaft on the 200 level. The ore bed here has been broken and dragged down several feet along two small subsidiary faults, the closest only 6 feet from the main fault. The stoped ground is only 6–15 feet wide, and presumably not more than 5 or 6 feet thick, in conformity with the thinness of the K bed. Very little of the K bed remains in the ground below the 300 level updip from a segment of the Nellie Bly fault (fig. 2).

The L bed crops out on the surface just west of the Argentine shaft collar, but its downdip projection could be tested by extending the 200 level northwest along the Blackhawk fault. However, the potential ground in the L bed is limited downdip from the 200 level by the position of the Nellie Bly fault (pl. 3*E*) which cuts off the L bed above the 300 level and drops it on the north to a position between the 300 and 400 levels (where it has already been stoped).

The hanging-wall side of the Blackhawk fault is not as extensively mineralized adjacent to the 200 level as the footwall side. An irregular blanket stope in the H bed, no longer accessible, was apparently worked, in part at least, as a sump from the 200 level. This stope borders and extends out 100 feet from the fault. Another small stope is in the C bed below a somewhat crosscutting porphyry sill bordering the Blackhawk fault just south of the junction with the 210 Drift fault.

Several stopes border the Rico Argentine dike which strikes nearly perpendicular to the trend of the Blackhawk fault in its hanging wall several hundred feet east of the richly mineralized block in the footwall, previously described. The stope in the H bed on the southeast side of the dike was mentioned in the discussion of the Blaine level. On the northwest side of the dike, stopes have been developed in the D and E beds between the 200 and 300 levels, and some stoping was done in the dike in this interval and above the 200 level.

Very little of the Honduras fault has been cut on the 200 level. It lies at the north edge of the workings 200 feet east of the Rico Argentine dike (pl. 3*D*) where it dips southwest at 77°–90° and shows a displacement of about 150 feet, down on the north. At the crosscut east of the dike, the fault has evidently split into two segments that dip northeast at 83° and 68°. Some warping of at least one of the segments is necessary to project the fault through a vertical 10- to 18-inch quartz vein that marks the best projection of the fault across the dike. The major displacement, however, appears to have veered southwest along the trend of the dike, corresponding to a similar change in direction of a major component on the Blaine level. As no longitudinal fault was recognized in the dike, this doubtless means that the dike was emplaced later than the main part of the Honduras faulting, a surmise also strengthened by the termination of the dike against the fault on the Argentine level.

Southeast of the Rico Argentine dike, the Honduras and Blackhawk faults are nearly parallel and are about 120–150 feet apart. Several ore deposits have been developed in the intervening block in the C, D, and E beds above the 200 level. A stope involving the C and D beds is continuous up to the Blaine level. The A and B beds were cut along the main haulage drift at the northwest end of this block, but they are not there mineralized.

300 LEVEL

The 300 level is 117 feet below the 200 level at the No. 3 shaft. The tunnel workings adjacent to the Blackhawk fault extend from 470 feet northwest of the Argentine shaft to 630 feet southeast of it, though only the last 500 feet of the latter stretch is actually on the fault. Farther southeast, the tunnel swings into the hanging wall similarly to the 200 level and extends an additional 1,300 feet. It has major crosscuts to the north and northeast; the northeast crosscut is along the general course of the Rico Argentine dike. The main tunnel branches near its end, a north branch largely following the Honduras fault and a south branch crosscutting to the south and reaching at least a segment of the Blackhawk fault (pl. 3*E*).

Crosscuts into the footwall of the Blackhawk fault have been minimal, consisting for the most part of developmental workings to undercut the stopes but including also the haulageway to the 517 shaft. Major ore deposits in the E, I-J, and K beds have already been mentioned in the discussion of the 200 level. The Nellie Bly fault produces a stratigraphic gap on the 300 level that includes the L bed (fig. 2). At the north end of the level is a stope in the lowest limestone of the upper Hermosa (unit 27 of the composite section) at its intersection with the Blackhawk fault.

The immediate hanging wall of the Blackhawk fault southeast of the Argentine shaft contains a narrow tabular stope along a subsidiary fault of small displacement at its intersection with the H bed. The stope is 10–20 feet wide perpendicular to the fault and extends nearly up to the 200 level.

Another hanging wall stope was developed in the E bed just north of the 210 Drift fault. The stope extends 110 feet out from the Blackhawk fault and in places is at least 20 feet thick. At its east side it is below a somewhat crosscutting porphyry sill. The updip margin is at the intersection of the ore bed with the 210 Drift fault, though in places the stope crosses this fault into unidentified strata south of it in the ground immediately adjacent to the Blackhawk fault.

Small stopes in the E bed in the first crosscut to the north, east of the No. 3 shaft, are of interest only in that they are as much as 390–460 feet from the Blackhawk fault. They are in the footwall of a small thrust fault.

Stopes along the northwest side of the Rico Argentine dike in the D and E beds were mentioned in the discussion of the 200 level. The one in the top 8 feet of the D bed extends as a winze somewhat below the 300 level where it is as much as 25 feet wide. Pipelike stopes are also present along both walls of the dike in the lower part of the C bed at its intersection with a 38° fault, the one on the northwest side apparently rising steeply through the porphyry dike to the 200 level at the upper end. A narrow inclined pipe stope in the C bed is also developed along the intersection of two small faults for 130 feet west from the dike.

A fairly narrow stope in the H bed along the southeast side of the dike extends from the 300 level up nearly, but not quite, to junction with the lower end of the extensive stope, in the same position, that extends from the 200 level to above the Blaine level. There is an additional pipe-like stope in the H bed which, at its lower end, somewhat below the 300 level, is 200 feet east of the dike but swings in upward and joins the stope along the dike at the 200 level. For most of this distance this latter stope is in the limestone along the top of a somewhat crosscutting porphyry sill. The stope is 9–25 feet wide and averages perhaps 15 feet high. In places, the porphyry was mineralized enough to have been stoped along with the replaced limestone. The lower end of this stope is about 500 feet from the Blackhawk fault.

The Honduras fault lies at an unknown distance within the southwest wall of the 300 level workings at the Rico Argentine dike intersection and is first cut by the main tunnel at a point 250 feet southeast of the dike. Here, it is perhaps 140 feet from the Blackhawk fault, but the two diverge somewhat farther southeast (pl. 3*E*). Some stoping of ore has taken place farther southeast, chiefly along, or adjacent to, the Honduras fault, but most of the stopes are no longer accessible. The complications produced by several obscure faults and igneous masses make correlation of the beds uncertain (pl. 3*E*), but the stopes are probably in the A, D, and E beds, and possibly in one or both of the intervening ones. Those stopes seen have been relatively small.

400 LEVEL

The 400 level is about 140 feet below the 300 level at the 517 shaft. The main haulage tunnel in the northwest half of the level is in the footwall of the Blackhawk fault, and explores the E to L beds adjacent to the fault over a fault length of 530 feet (pl. 3*F*). At the intersection with the E bed the fault has a displacement of about 35 feet, which is less than the thickness of the E bed. A part of the E bed extending for 30 feet from the fault on the 400 level has been stoped down to the 600 level, though this stope crosses to the E bed in the hanging wall of the fault somewhere above the 500 level. The H bed for 25 feet adjacent to the fault has been stoped updip nearly to the 300 level. The I-J and K beds are in the stratigraphic gap on the 400 level produced by the Nellie Bly fault (fig. 2), though the top of a K bed stope barely reaches the level. The north end of the level terminates at a stope about 10 feet wide in the L bed, whose upper few feet has been stoped downward to the 500 level and upward to the Nellie Bly fault. The L bed has also been extensively stoped above the level, probably to above the 300 level, in the immediate hanging wall of the Blackhawk fault; there the stope is 10–20 feet wide.

The southeast half of the 400 level is in the hanging wall of the Blackhawk fault, and the tunnel (as of 1969) is almost entirely a drift, 650 feet long, in the E Bed. This bed contained several ore bodies updip from the level, and one of the largest stopes continues down to the 600 level. From the 400 to the 500 level, the ore was in two roughly parallel pipes with an intervening barren pillar, but the pipes coalesced at the 500 level and below this a single pipe was stoped down to the 600 level. Although this stope had not been surveyed at the time of the geologic examination, estimates were made of its dimensions above the 400 level. It crosses the 400 level about 110–120 feet from the Blackhawk fault, climbs up the dip of the bedding for an estimated 80 feet (as projected on a horizontal plane), and then swings more nearly parallel to the strike of the fault. In its upper part, it must be closer to the fault than at the level crossing, but the fault is nowhere cut. Over a length of 300 feet above the 400 level, the stope shows an average width of 15–20 feet and a height of 25–30 feet, except near the end where the height decreases to 15 feet. Smaller stopes in a more intricate pattern extend farther and eventually extend back east to the main drift at and near its end, 450 feet from the beginning of the stope. The control for the ore body is obscure, but this general area has been affected by bedding faults that are visible near the top of the E bed, and the 210 Drift fault must lie just south of the stoped ground (pl. 3*F*). At the crossing of the main level, the stope is on the axis of a shallow synclinal trough, though this structure cannot be extended very far up the stope.

500 LEVEL

The 500 level is the continuation of the long crosscut from the St. Louis tunnel into Rico Argentine ground but is worked through the 517 shaft. It is about 102 feet below the 400 level. The stratigraphic sequence on the level is complicated by several segments of the Nellie Bly fault (pl. 3*G*), most of which are so tight and obscure as to belie their considerable significance. The level develops both the foot and hanging walls of the Blackhawk fault.

In the footwall, the E and lower beds (down to the B bed) were not mineralized. Both the H and I-J beds were eliminated on or slightly above the level by segments of the Nellie Bly fault (pl. 3*G*). From the K bed, a replacement blanket of considerable extent was mined between the 600 and 400 levels. Although this ore bed was thinned even below its usual 4–5 feet thickness by a bedding fault (to which, however, the mineralization can be attributed), the ore blanket extended as much as 100 feet into the footwall of the Blackhawk fault and had a mining length above the 600 level of about 280 feet as measured on the ore bed (fig. 2). The L bed in the footwall was mined in a narrower stope perhaps 25 feet wide adjacent to the fault and extending from the 500 level to well above the 400 level.

In the hanging wall, two pipelike stopes in the E bed, extending from the 600 through the 500 to, and one of them above, the 400 level, have been described under the 400 level heading. There was also a stope above the 500 level in the I-J bed. This stope bottomed on the northeasterly fault that may be related to the Nellie Bly system (see p. 46).

600 LEVEL

The 600 level, 67 feet below the 500, is developed by a drift 700 feet long which follows the Blackhawk fault except at its southeast end where it cuts into the hanging wall (pl. 3*H*). The workings explore the section from the E to L bed on both sides of the fault. In the hanging wall, ore was found in the two ore pipes in the E bed, already described in the discussion of the 400 level. In the footwall, stopes have been developed in the H (presumably), I-J, K, and L beds. Because of complications related to the Nellie Bly fault system, the H bed is not exposed in the footwall near the Blackhawk fault on the 600 level but is presumed to be the ore bed in a stoped block of ground between the 600 and 500 levels, though the stope was not accessible when the ground was examined in 1969. The other three ore beds have stopes that extend 80 feet (L bed) to 100 feet (K and I-J beds) into the footwall on the level, and updip to or above the 500 level. The stope in the I-J bed is in the lower 5–8 feet of the limestone, whereas that in the L bed is in the top 7 feet.

YELLOW JACKET (PHOENIX) GROUP

The Yellow Jacket group of mine workings is largely in the block of ground between the Last Chance and Nellie Bly faults on the southeast slope of Nigger Baby Hill. The group comprises several northwest-trending tunnels, some of which pass under old workings that were originally developed through the Grandview and Cobbler shafts on the nose of the hill. The most extensive tunnels are now

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caved at the portals, but they were mapped while the ground was open during 1930–31. Beginning with the lowest, the 700-foot level (No. 6) starts very close to the old Last Chance portal and runs N. 27° W. for 310 feet, then turns to N. 38° E. for an additional 460 feet; the altitude of its portal is about 9,340 feet (pl. 2*B*). The portal of the 500-foot level (No. 5), 290 feet to the northwest, is at an altitude of 9,510 feet and is near or at the later bulldozed mining road that leads from the Mountain Spring and adjacent mines on CHC Hill to the Rico Argentine mill on Silver Creek. The workings of this level are irregular, but a major drift leads northwest to barely intersect the Nellie Bly fault at its end, 1,180 feet from the portal, and a more westerly drift follows the general course of the Yellow Jacket fault (pl. 2*B*). The 400-foot level (No. 4) has three portals at an altitude of 9,618 feet (pl. 2*A*), and has the most extensive workings, irregular in pattern, of any level. A crosscut to the northwest on this level crosses the Nellie Bly fault and extends 260 feet into its hanging wall; other workings of more westerly trend intersect segments of the Yellow Jacket fault in five places, though none of the workings follow the fault for more than 60 feet (pl. 2*A*). The 300 A level (No. 3½), at an altitude of 9,670 feet, starts just south of the Yellow Jacket fault but swings onto this fault zone a short distance inside the portal and follows the general course of the fault west-northwest for about 880 feet; at 480 feet, a drift on a more northwesterly course extends for 550 feet. Other and smaller workings include the 300-foot level (No. 3) at an altitude of 9,690 feet, the 200-foot (Woods Hole) level at 9,775 feet, and several others (Nos. 2 and 1) that have long been caved. With minor exceptions, only those workings within 200 feet of the Yellow Jacket fault were productive of ore.

Nigger Baby Hill was the site of some of the earliest mines developed in the Rico district, but they were in oxidized ores high on the nose of the hill. The early mine workings are described by Ransome (1901, p. 375–383), but at the time of his report, the small 400 level was in ore "too poor to pay for working," and the portal was caved. Much of the difficulty on these lower levels lay in the refractory nature of the zinc-bearing sulfide ore which at that time was heavily penalized for its zinc content. After perfection of the flotation process for separating zinc and lead sulfides, these complex ores became exploitable. There was a major surge in mining activity on Nigger Baby Hill in the 1920's, particularly in the latter half of the decade, when the Falcon Lead Co. operated the Yellow Jacket group of claims, and presumably the major developments on the No. 4 and No. 5 levels were made at that time.

The Yellow Jacket fault zone was cut in the southwesternmost workings of levels 3½, 4, and 5. The stratigraphic dip on the north side is 25°–40° NE., but across the fault zone the direction is reversed to southwest and south at 40°–65°. In the ground adjacent to the fault, several subsidiary fractures of roughly parallel strike and steep dip were produced, and differential slippage between the strata produced bedding faults. Both types of break were mineralized.

The stratigraphic horizon is near the base of the middle Hermosa. The A bed, 18 feet thick and dipping northeast at 32°, is cut on the No. 6 level at 220 feet after the tunnel bends northeast, but it is too far from the Yellow Jacket fault to have been mineralized on this level. Updip, it passes about through the former portal of the No. 5 level, and, at closer approach to the fault above that level, it was mineralized where broken by a N. 70° W. fracture about 100 feet on the north side of the Yellow Jacket fault. The resultant ore body was mined in the Koenig stope, which rises to the west diagonally up the dip to the 400 level, above which the ore body was mined in the Beecher stope. The limestone was replaced downdip from the fracture to a maximum distance of 50 feet in the Koenig stope and 45 feet in the Beecher stope. Replacement updip from the fracture was minor. The A bed was also mineralized on the No. 5 level to a minor extent in the Gray Copper stopes which are more than 500 feet from the Yellow Jacket fault and closer to the Nellie Bly fault (pl. 2*B*). In these stopes the common sulfides were accompanied by considerable tetrahedrite.

Above the A bed, thin bedding veins in clastic strata a short interval below the B bed were mined locally on the No. 4 level, but the stopes are small. The B bed, only 3 feet thick, contains a little disseminated mineral but was not stoped on the 400 level, though a little ore was taken from it updip in minor stoping on the short No. 3 level, which is chiefly a drift on this bed. A thin bedding vein at the base of a sandy shale between the B and C beds was stoped somewhat more extensively, over a length of 100 feet and width of 70 feet, above the No. 3 level. The C bed was cut at four places along the northeast side of the No. 4 level, including the entry from the northeast portal, and in a raise from the No. 5 level. Except for a little thin ore along its base adjacent to a porphyry body, mined in the Herron stope on the No. 4 level, the C bed has no known mineralization, but it may have contained ore updip and closer to the Yellow Jacket fault in higher workings that have been long caved.

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Strata of the lower Hermosa below the A bed were cut on the north side of the Yellow Jacket fault on the Nos. 5, 4, and 3A levels. Although doubtless lower strata are cut on the No. 5 level, the section here is more broken and complicated by proximity to the fault. The least complicated section was cut on the No. 4 level, and shows a virtually unbroken stratigraphic sequence of 160 feet below the A bed. At 70 feet below the A bed is a 2½-foot bed of shaly limestone that has been slightly mineralized and that has been prospected for about 40 feet (516 drift) on the 500 level. All other strata are sandstones and shales. Bedding slips in some of these clastic strata have been somewhat mineralized in places but not to economic grade.

A relatively small stratigraphic thickness has been cut on the south side of the Yellow Jacket fault in the short distance between the fault and the porphyry mass that forms the block to the south. The strata have been faulted and steeply tilted away from the main fault zone. Although no definitive limestone is present in this clastic series, the strata are assumed to be middle Hermosa on the premise that the Yellow Jacket fault is of normal character, with downthrow on the south. However, if the displacement on the fault zone should be small, the stratigraphic horizon might still be lower Hermosa on the mine levels, though the steep southward dip makes probable the presence of middle Hermosa at the surface, as depicted on plate 1.

The fracture zone in clastic strata along the Yellow Jacket fault has been mineralized and was stoped above the No. 3½ level. Near the portal of this level, a breccia along the fault zone as much as 35 feet wide has some of its fragments replaced by black sphalerite, galena, and pyrite to yield a rather low-grade ore body that was partly stoped. Farther west along the fault, the breccia pinches out but the mineralization was somewhat intensified, and considerable stoping was done above the level within 10–20 feet of the main fault fracture. Still farther west, beyond the 550-foot drift that diverges to the northwest into the footwall, the south prong of the tunnel follows a nearly vertical vein that gradually diverges on the south side of the fault to an ultimate distance of 40 feet from the fault. This vein was stoped over a width of 10 feet and a length of about 250 feet for a considerable distance above the level. The Woods Hole level, about 105 feet higher than the No. 3½ level, stoped a vein of parallel strike but generally lower northward dip and located about 100 feet to the south.

Descriptions given by Ransome (1901, p. 375–383) of the ore deposits in the early mine workings indicate that most of the deposits at higher levels were probably also veins in clastic strata near the Yellow Jacket or Nellie Bly faults. Some were steep, others were evidently bedding veins dipping northeast at about the angle of stratigraphic dip. As described, some of the veins lay beyond the Nellie Bly fault in upper Hermosa strata.

FALCON MINE

The Falcon mine workings consist of three tunnels on the nose of Nigger Baby Hill a short distance above the mine road up Silver Creek. The upper tunnel has long been caved, but the middle and lower tunnels were accessible in the 1950's. The middle tunnel, which has the most extensive workings, is at an altitude of 9,250 feet, and the lower tunnel is at 9,175 feet.

The strata cut by the tunnels are predominantly the basal part of the lower Hermosa and top part of the underlying Larsen Quartzite. These beds dip southward at about 30°. The tunnels run north into the hill, starting in the lower Hermosa and crosscutting to its base, within a distance of 100 feet at the middle tunnel. The ore, which is present chiefly in the middle tunnel, is a sulfide replacement body containing pyrite, sphalerite, and some galena and chalcopyrite in dolomitic limestone at the base of the Hermosa. The presence of chlorite and tremolite among the gangue minerals suggests that the deposit is a somewhat higher temperature replacement than the bulk of the ore deposits in the district. Although the ore bed is 7 feet thick, most of the ore is concentrated in the basal 1–3 feet. A northward-dipping sinuous fault of only a few feet of throw, down on the north, traverses the stoped ground at the end of the entry tunnel and may be one of the controls for the ore. The stope length along the bedding strike amounts to only 180 feet, and the stope width, as projected onto a horizontal plane, is somewhat less.

An exploratory drift has been run eastward from the stope for the most part along the top of the Larsen Quartzite, although relations are somewhat complicated by the sinuous fault and by a small dike-like body of porphyry. At 310 feet, this tunnel turns northeast, cuts first across the fault, which has increased in throw, then crosscuts diagonally the basal part of the Hermosa (brought down by the fault) and into the Larsen Quartzite, here dipping 36°–49° S. After traversing 88 feet in this quartzite (cutting down 55 ft stratigraphically below its top), the tunnel crosses what appears to be a fault dipping south-southwest at 75°, and enters a structureless quartzite, believed to be the Uncompahgre Quartzite.

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The fault intersection is 523 feet from the middle tunnel portal in a N. 56° E. direction and is probably a segment of the Smelter fault. The prospect tunnel ends after penetrating 40 feet of the Precambrian quartzite. Although a little galena, sphalerite, and pyrite show in fractures in this quartzite, the judgment of the miners in stopping further exploration in this direction seems sound.

AZTEC MINE

The Aztec mine is west of the Dolores River north of Rico, on the north bank of Aztec Gulch. The workings consist of two tunnels, the lower one, at the end of the access road, at an altitude of 9,540 feet and the upper one, at 9,592 feet. The upper tunnel follows very closely the quartz vein on the Nellie Bly fault for a total length of 525 feet, striking N. 70° W. The lower tunnel drifts on the vein for 210 feet; at 40 feet from the end of this drift, a crosscut of somewhat sinuous pattern has been extended in a general north-northwesterly direction into the hanging wall of the vein for a distance of about 225 feet.

The wallrocks are sandstones, shales, and minor dolomite and shaly limestone of the lower Hermosa dipping north-northeast at 15°. Dikes and small irregular bodies of igneous rock, present in both walls of the fault, indicate that the original faulting preceded at least some of the igneous activity. The igneous bodies include, on the north side of the fault, a dike of the normal latite porphyry of the district, and, just north of this, a dike of alaskite porphyry about 15 feet thick. Both of these are exposed on the outcrop north of the portals of the tunnels and are also cut in the mine workings. Other dikes and sills of the latite porphyry and less regular small masses of both igneous types are also present on both sides of the fault within the workings.

The quartz vein is 1–6 feet thick in the mine workings. It contains a little pyrite in places, but most of the mineralization in the mine is fine-grained replacement sphalerite and galena of varying richness in the sedimentary rocks immediately bordering the quartz vein. The mine has never been very productive but was one of the earliest worked in the district because of the silver contained in scattered pockets of oxidized material.

NORA LILY MINE

The Nora Lily mine consists of two tunnels, now caved, driven eastward on the Last Chance fault zone from the west side of Nigger Baby Hill. The lower tunnel, which was the main working level, is at an altitude of 9,072 feet and had an original length of about 700 feet. Only the front 400 feet was accessible in 1931. A crosscut 300 feet from the portal goes north-northeast into the hanging wall for 335 feet. The upper level, at an altitude of 9,120 feet, has a length of about 295 feet virtually parallel to the lower level though offset 7–20 feet north of it, owing to the dip of the vein; an additional 35 feet at the end bears northeast. Any extensions made in the workings during World War II were, at most, negligible.

The portal of the lower tunnel is virtually on the fault contact between Uncompahgre Quartzite on the south and a thick latite porphyry mass on the north. Developments in the mine show that the porphyry mass is a thick sill whose undulatory base is exposed in the crosscut. Both tunnels are driven on a fault vein in the highly altered porphyry, presumably just north of the quartzite contact, though this contact was not cut in the workings. The vein dips southward at 70°–85°. On the lower level a second vein of parallel strike, dipping southward at 50°–55°, is 5–15 feet south of the main vein and was intersected in two short crosscuts; a third vein is present locally between the other two. All unite upward into the single vein on the upper level.

The ore consists of sphalerite, pyrite, and galena, irregularly distributed along the veins in thicknesses as great as 2 feet. Some ore has been shipped, but the mine has never been very productive.

PRO PATRIA AND REVENUE MINES

The Pro Patria and Revenue tunnels are nearly parallel crosscuts that enter the northern part of Newman Hill at altitudes of 9,425 and 9,576 feet, respectively. Their general course is about S. 30° E. for a quarter of a mile to intersection with the veins, which strike northeast-southwest. In the vein zone there is an upper level, 60 feet above the Revenue level and connected with that level by a steep inclined raise.

The rocks cut in the workings are lower Hermosa, dominantly sandstones and arkoses and subordinately shales, dipping south to southwest at angles of 10°–30°. These rocks contain a few sills and dikes of the latite porphyry. A few thin seams of shaly limestone in the sequence have not been especially affected by the mineralization.

Five or six veins have been developed, though unequally, within a vein zone that is about 500 feet wide. At least 900 feet of drifting on one vein at the Revenue level connects at the southwest end with old drifts from the Laura mine which are said to be (label on mine map) on the Enterprise vein. However, Rickard (1897, p. 970) deprecates attempts

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to extend specific veins of Newman Hill indefinitely along the strike because of the tendency for individual veins to die out and be overlapped by others in similar position; neither he nor Ransome (1901, pl. 29) extended the Enterprise vein northeast of the Laura shaft. The veins are on faults of small throw, maximum 17 feet where determinable, striking generally between N. 28° E. and east-west, averaging perhaps N. 45° E. They are somewhat sinuous between straight stretches and may locally bend through east-west to an east-southeast strike for short stretches. Dips are 65°–90° in either direction. Within these dips, the fault displacements may be normal or reverse.

The veins are broken and slightly offset by numerous small faults of northwest to north strike which dip northeast at 40°–70°, rarely to 90°. The offset is generally left lateral, though in part, right lateral. Although a few of these cross faults are weakly mineralized, most contain only gouge, quartz, and a little pyrite. Because these cross faults are down on the northeast, they repeatedly drop updip extensions of the strata, thus tending to repeat, on a given mine level, strata in a relatively small section of the total stratigraphic sequence. The porphyry dikes mostly follow this northwest system of fractures, but the veins continue unbroken across the dikes. Ransome (1901, p. 320–22, 331–34) has discussed the relation between the northeasterly and northwesterly vein system in other parts of Newman Hill, and the relations may be more complex than simple faulting of an earlier by a later system (see p. 76).

The veins in the Pro Patria-Revenue workings are generally only a few inches to a foot thick, rarely lensing to a maximum of 2 feet. They contain pyrite, sphalerite, galena, and a little chalcopyrite with a quartz and commonly also rhodochrosite, rhodonite, and rarely calcite, gangue. Some of the veins are crustified, the rhodochrosite and rhodonite tending to occur along the borders and the quartz in the centers. Scattered small shoots have been found that are rich in silver and free gold, the silver occurring, at least in part, as polybasite.

The mines have been worked intermittently but generally only during periods of high base-metals prices. In the early days of the Rico camp, the same or similar veins were worked, chiefly for silver, farther southwest in Newman Hill where they were far more profitable and where they acted as feeder channels to a blanket replacement deposit of exceptional richness in residual material derived from the leaching of gypsum. The blanket deposits were not found northeast of the Laura shaft and were depleted before 1900. Ransome (1901, p. 308–340) gives a very full account of the ore deposits in that area.

FOREST PAYROLL MINE

The Forest Payroll mine is at an altitude of 10,137 feet, on the spur leading northwest from Dolores Mountain, high on the left slope of Allyn Gulch. It is reached by a mine road that starts at the south end of Rico, climbs around the south end of Newman Hill, and cuts back northeast as a high-level road across the whole length of Newman Hill. The main working is an entry adit, 400 feet long, going S. 29° W. into the hill, with cross drifts that follow the intersected veins. Only one vein, 280 feet from the portal, has been developed to any appreciable extent over a length of 480 feet, of which 85 feet is northwest of the entry adit and the rest southeast of it. Another vein near the end of the adit has 80 feet of drifting on it. Higher levels up raises in the mine were inacessible in 1958.

The rocks cut by the mine workings on the adit level are sandstones, arkoses, and some shales of the lower Hermosa, dipping generally east to southeast at about 10°. Two porhpyry dikes, 12 or 13 feet thick, trending about N. 70° W. parallel to the vein system, are intersected at 80 and 150 feet from the portal; another porphyry body of undetermined shape, but probably a dike, is cut for a short distance along the vein walls in the long crossdrift to the southeast.

The ore deposits consists of quartz veins 2 inches to 1 foot, or rarely, to 2 feet thick, containing pyrite, sphalerite, galena, and a little chalcopyrite. Some oxidation has produced considerable limonite, cerussite, and anglesite. The average strike of the vein that has been most developed over a length of 480 feet is N. 72° W., and the dip is nearly vertical. However, its strike is somewhat sinuous between straight stretches, and segments vary between N. 65° W. and east-west. Another vein near the end of the entry adit averages about east-west in the 80 feet developed but swings from N. 83° W. at its east end to N. 74° E. at its west end; its dip is vertical to 80° S. The veins are developed on faults of small throw; the throw on the main vein is about 8 feet, down on the south.

Some stoping has been done virtually from the surface at a higher level on the property, on an irregular blanket deposit in a thin and presumably limy zone of the lower Hermosa. The ore has here been oxidized to limonite containing cerussite, anglesite, and residuals of galena, with some quartz gangue.

The Mountain States Mining Co. operated the Forest Payroll mine in the latter half of 1965 and first half of 1966 and shipped 396 tons of ore during this period. The early shipments (81 tons) were lead ore, and the later shipments (315 tons) were lead-zinc ore, averaging as follows:

		Lead ore (81 tons)	Lead-zinc ore (315 tons)
Lead	Percent	32.1	9.8
Zinc	do	1.2	8.4
Copper	do	1.15	1.37
Arsenic	do	0.09	0.135
Antimony	do	0.15	----
Silver	oz per ton	19.0	5.9
Gold	do	0.025	0.014

IRON CLAD (SILVER CLAD) MINE

The Iron Clad mine, worked for many years by Myron Jones, came under the control of Silver Bell Mines in 1969. The mine is below the Engel's mine road on the west side of the Dolores River southwest of Rico, in the first hundred feet above the valley floor. The workings are two tunnels, which enter the hill in a southwesterly direction. The No. 1 (lower) tunnel is at an approximate altitude of 8,725 feet, and the No. 2 tunnel, whose portal is 175 feet to the southwest, is about 75 feet higher. Most recent development has been in the No. 1 tunnel.

The stratigraphic horizon is in shales, sandstones, arkoses, and some shaly limestones of the lower Hermosa, dipping south at 15°. The sequence is capped by a porphyry sill about 8 feet thick where it is cut near the south end of the upper tunnel workings. This sill forms the back at the south end of the lower tunnel and in stopes above this tunnel. The known mineralization is below the sill and comprises veins on fractures of small (0–4 ft) displacement and replacement bodies in shaly limestone and limy shale within a few feet of the feeding veins. The veins trend northeastward: the two major ones, 75–140 feet apart on the lower level, trend between N. 20° E. and N. 45° E., and a third vein, on which the lower tunnel enters the hill, trends N. 65° E. over much of its course. Dip is to the northwest at 50°–80°. The northwest vein has been stoped on both tunnel levels. Vein thickness is generally 1–12 inches, but may be as thick as 2 feet, particularly in the sandstones and arkoses where the veins also have a tendency to horsetail. Replacement bodies in more limy strata centered on the veins are 2–15 feet wide and as much as 10 feet thick.

The ore consists of massive sphalerite, galena, pyrite, and chalcopyrite. It contains a few ounces of silver per ton of ore, the veins in the coarse arkose being somewhat richer than those in the more shaly wallrocks. At least part of the silver is in the silver minerals polybasite, pyrargyrite (ruby silver), and argyrodite. Gangue minerals include quartz, which is especially conspicuous in the replacement ore bodies, and a little calcite.

The mine has not been very productive in the past from lack of small-scale milling facilities. In 1969 the ore was trucked to the Silver Bell mill at Ophir for milling. As the developed horizon is in the lower Hermosa, presumably not far above the Leadville-Ouray Limestones, the management was particularly interested in testing this lower ore horizon by drilling. According to newspaper accounts (Dolores [Colorado] Star, Nov. 28, 1969), the Silver Bell Mines Co. initiated such a drilling program in the fall of 1969 and intercepted lead-zinc ore in the limestone at a depth of 625–675 feet.

JONES GOLD MINE

The Jones gold mine has developed a unique type of mineral deposit in the Rico district in that the total values are in free gold. The deposit has not been very productive because the pockets containing the gold have been scattered, and considerable development work is necessary between pockets. However, the pockets, when found, are rich enough to encourage further search.

The tunnel is on the west side of the Dolores River southwest of Rico, just above the Engel's mine road, at an approximate altitude of 8,845 feet. The property is known as the St. Louis claim, which is not to be confused with the many other properties in the district worked in the 1920's and 1930's by the St. Louis Smelting & Refining Co. The tunnel enters the hill in a westerly direction, and after 160 feet, bends southwest for an additional 335 feet. It is driven in sandstones and shales of the lower Hermosa which dip about 10° between southwest and south. A porphyry sill exposed in the mine may be the same sill as in the Iron Clad workings to the southeast.

The gold occurs (1) chiefly in a thin shale breccia just above a bedding fault about 15 feet above the porphyry sill; (2) in fractures of no perceptible displacement which sole on the breccia; and (3) in a bedding seam, ranking second in richness, at the top of the fractures and about 30 feet above the shale breccia. The following section gives the stratigraphic setting:

	Thickness (feet)
Top	
Bedding seam, second richest ore horizon	1±
Dark shale and sandy shale, containing veins	30±
Shale breccia, finely fragmented; major ore carrier	1–2
Clay gouge	max. 1/6
Dolomite, light-gray, hard, tough, finely pyritic	1
Black shale, barren	15
Porphyry sill in which feldspar phenocrysts are kaolinized	14

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The veins are very irregular but, on the average, dip northwest at about 60°. Any gold is concentrated on their footwalls.

The gold is free and generally associated with a little pyrite which, however, carries only 0.02 ounce gold per ton. Calcite and a little loose quartz are also commonly present, but, in much of the ore, the free gold has no gangue.

ATLANTIC CABLE MINE

The Atlantic Cable mine is in the town of Rico, just west of the main street and just north of Silver Creek. It is entered through a shaft that was sunk before 1900. During World War II the shaft was pumped out by the Rico Argentine Mining Co., and some zinc-lead-copper ore was produced. The following account is largely abstracted from Ransome (1901) and Varnes (1944).

The mine has three levels, at 45, 62, and 183 feet below the surface. The two upper levels are in marbleized limestone of the Leadville or Ouray Limestones which dip south to southeast at about 25°. The shaft was sunk in a high-grade ore body consisting of lead, zinc, iron, and copper sulfides and specular hematite. The main sulfide ore body occupies a generally central position within a larger mass of specularite, magnetite, and chlorite, following a general northwest fracture zone marked by quartz stringers. The iron oxide body has been developed over a length of about 400 feet and is mostly 40–60 feet wide, but widens at both ends, to 150 feet at the southeast end. The richer bodies of sulfide ore within this iron oxide mass have been stoped, but pods and irregular masses of pyrite, sphalerite, galena, and chalcopyrite occur scattered through the mass of "black iron" beyond the confines of the main sulfide mass. At many places a band of lead and zinc sulfides 1 inch to 1 foot thick lies at the contact between the iron oxides and the enclosing marble. The mineralization is typical of contact-metamorphic ore deposits.

SUGGESTIONS FOR PROSPECTING

In massive sulfide replacement bodies in middle Hermosa limestones, the lead-zinc-silver ore shows a pronounced tendency to be confined to the outer edges of the pyrite cores. As the pyritized areas are, in general, larger than their lead-zinc rims, these spatial relations suggest that, if massive pyrite is intersected by a drill hole or mine working, a narrow but potentially rich target for further prospecting is the contact of this pyrite with the surrounding limestone. Although not enough ore bodies have been studied to demonstrate these same spatial relations in places where the Leadville-Ouray Limestones are ore bearing, presumably the same pattern of ore distribution could hold.

The future of the district is believed to lie mainly in the possibility of limestone replacement deposits at two general stratigraphic levels—the limestones of the middle Hermosa and those of the Leadville-Ouray. The former contributed most of the base-metal ores of the past and are currently being exploited, whereas the latter are still largely unexplored. Favorable loci for mineralization are along intersections with the Blackhawk and closely related faults or with such porphyry dikes as the Rico Argentine dike.

The middle Hermosa limestones near their intersections with the Blackhawk fault have been well explored in the footwall of the Princeton fault in CHC Hill. The conclusion of the Rico Argentine Mining Co. that this ground is virtually exhausted and their decision to abandon the area seem justified.

Current mining by the Rico Argentine Mining Co. is in the middle Hermosa limestones along the Blackhawk fault in the hanging wall of the Princeton fault. However, not all the limestone beds are mineralized. Their sequence as given in the generalized section (p. 24) and their geometry in space, as depicted on plate 3, should aid in more clearly defining targets for exploration. Because the A bed has been cut in so few places in the Rico Argentine mine, little is known of its thickness and susceptibility to mineralization in this mine. If it should prove to be a worthwhile target, there is a large block of ground between the Blackhawk and 210 Drift faults in which the intersection of the A bed with the Blackhawk fault or the Rico Argentine dike would be accessible from the 300 and lower levels. North of the 210 Drift fault, all the limestone beds below the E bed would appear to be acceptable targets at their intersections with the Blackhawk fault, though exploration of the D, C, and B beds on the 500 level (pl. 3*G*) has been fruitless. The intersection of the middle Hermosa with the Blackhawk fault plunges northward from the block of ground in which the mining company is currently working, and all limestone beds should be considered potential loci for ore shoots down to the intersection with the Princeton fault.

The limestone of the Leadville-Ouray sequence has yielded ore in the structurally high area in and immediately adjacent to the townsite of Rico. Because it is here close to the surface, it has been accessible to shallow exploration. Elsewhere, it can be reached only by moderate to deep drilling at

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greater expense and with attendant disadvantages in the delineation of targets. Obviously, favorable areas would be where the Leadville-Ouray Limestones underlie known mineralization at higher levels.

One of the most obvious of promising areas is in the general vicinity of the Iron Clad mine, where base-metal veins containing silver minerals have been worked in the lower Hermosa. Initial drilling was done here by the Silver Bell Mines Co. in the fall of 1969, and newspaper accounts (see p. 94) indicate that mineralized ground, presumably in the Leadville-Ouray, was struck at a depth of 625–675 feet. Prospect workings higher up the hill within a quarter of a mile west of the Iron Clad tunnels reveal base-metal mineralization in the lower Hermosa that would indicate equally favorable targets in the underlying limestone, but exploration from the pertinent sites would require an additional depth of drilling or sinking to the target ground.

Another area that would normally invite attention is the fractured zone that contains the veins formerly worked for silver in Newman Hill. However, intervention of the thick porphyry sill between the vein-bearing ground and the Leadville-Ouray Limestones makes the depth to the limestones about 1,000 feet, even when holes are drilled from inside the long Lexington tunnel. Two such holes (1 and 2) drilled by the Pelleyre Mining Co. in the vicinity of the Jumbo shaft are reported to have contained a little pyrite, galena, sphalerite, and specularite in the limestone interval, but no significant mineralization. The other two Pelleyre holes (3 and 5) in Newman Hill were outside the richly mineralized area; one of these (3) contained a little specularite and base-metal sulfides, including chalcopyrite, in the Leadville-Ouray, but no ore.

The attempt by the St. Louis Smelting & Refining Co. to explore, from the St. Louis tunnel, the deep limestone adjacent to the Blackhawk vein ended in failure to reach the Leadville-Ouray. Nevertheless, the concept on which the exploration was based has merit. The failure may have been partly due to the error in the estimated thickness of the lower Hermosa. If the surmise is correct that the porphyry intercepted at 630–742 in drill hole 3 is at approximately the same horizon as the Newman Hill sill (see p. 81), the Leadville-Ouray should be reached at an approximate depth of 1,000 feet on the hanging-wall side of the vein, and at about 950 feet on the foot-wall side; this conclusion is based on the assumption that the major fault displacement along the St. Louis tunnel is on the alaskite porphyry dike (see p. 81).

The Leadville-Ouray Limestones should be accessible to exploration in the footwall of the Blackhawk fault in the deeper workings of the Rico Argentine mine. On the 300 level, the southernmost working enters the Blackhawk fault zone, though it may not have completely penetrated this zone. From the end of this working, diamond-drill hole 364 extends 89 feet nearly horizontally into the footwall of the fault (pl. 3*E*). The core between 46 and 89 feet was logged by the company geologist as "schist or quartzite." A sample of this core shown to the author was a highly pyritic quartzite. If this core represents the Uncompahgre Quartzite rather than a locally quartzitized phase of the lower Hermosa, the horizon of the Leadville-Ouray must be in the footwall of the fault somewhere between the Blaine and 300 levels. A logical place to test this surmise would be near the end of the 208 drift on the 200 level (pl. 3*D*).

The large variation in thickness of the Leadville-Ouray Limestones over a relatively small area suggests some caution in prospecting this unit. In a structurally complex, but generally positive, area along the Rico dome, the ground may have been structurally active at different periods in the geologic past, including the time preceding deposition of the Larsen Quartzite. Indeed, this quartzite may be the record of very abrupt uplift and local erosion that cut as deep as the Precambrian. Under such conditions, the Leadville-Ouray could be entirely absent in places. Subsurface exploration of one form or another will be necessary to define the existence, thickness, and mineral potential of the formation.

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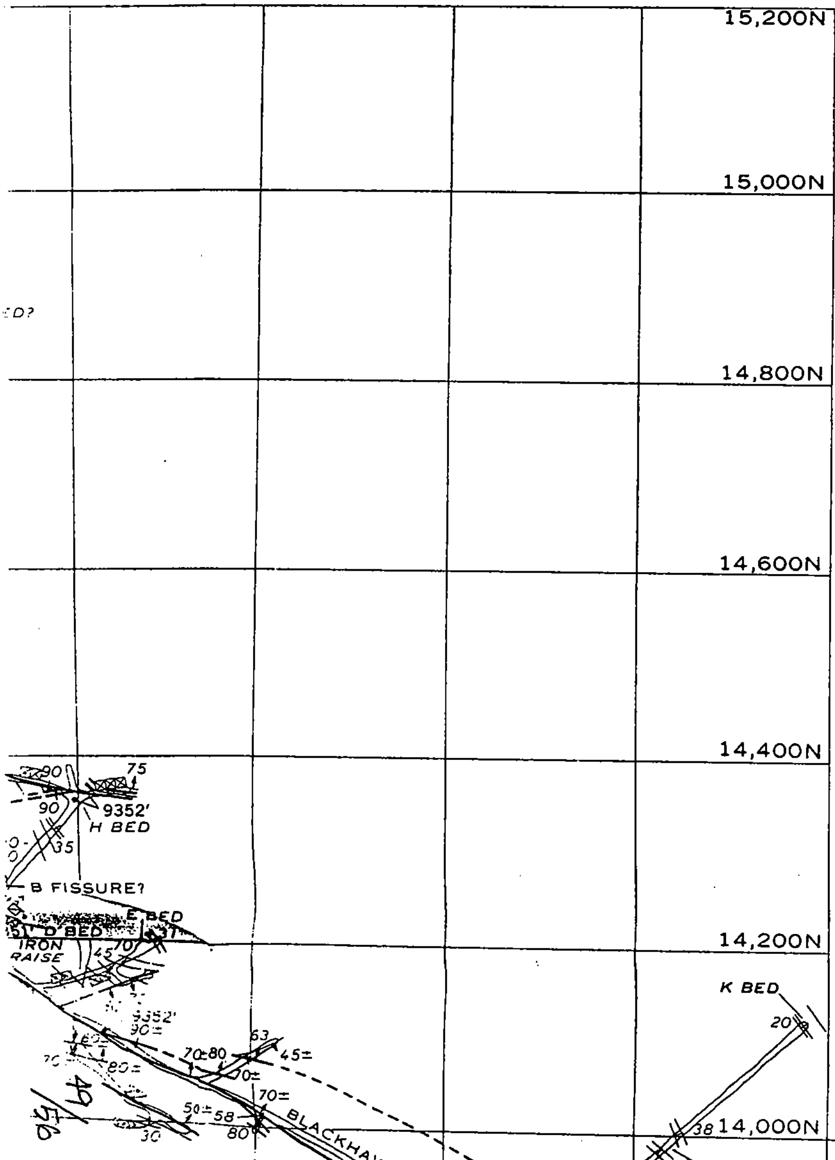
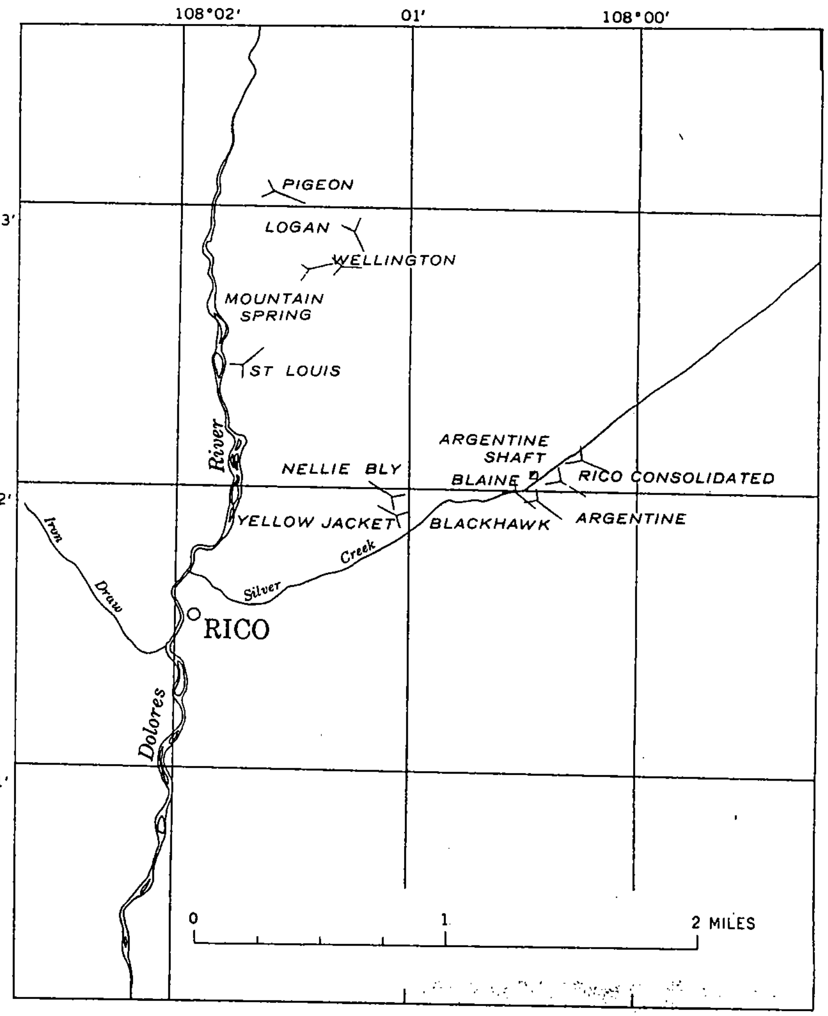
PLATE 3





MAP SHOWING LOCATION OF MAPPED WORKINGS
IN RICO MINING DISTRICT, COLORADO

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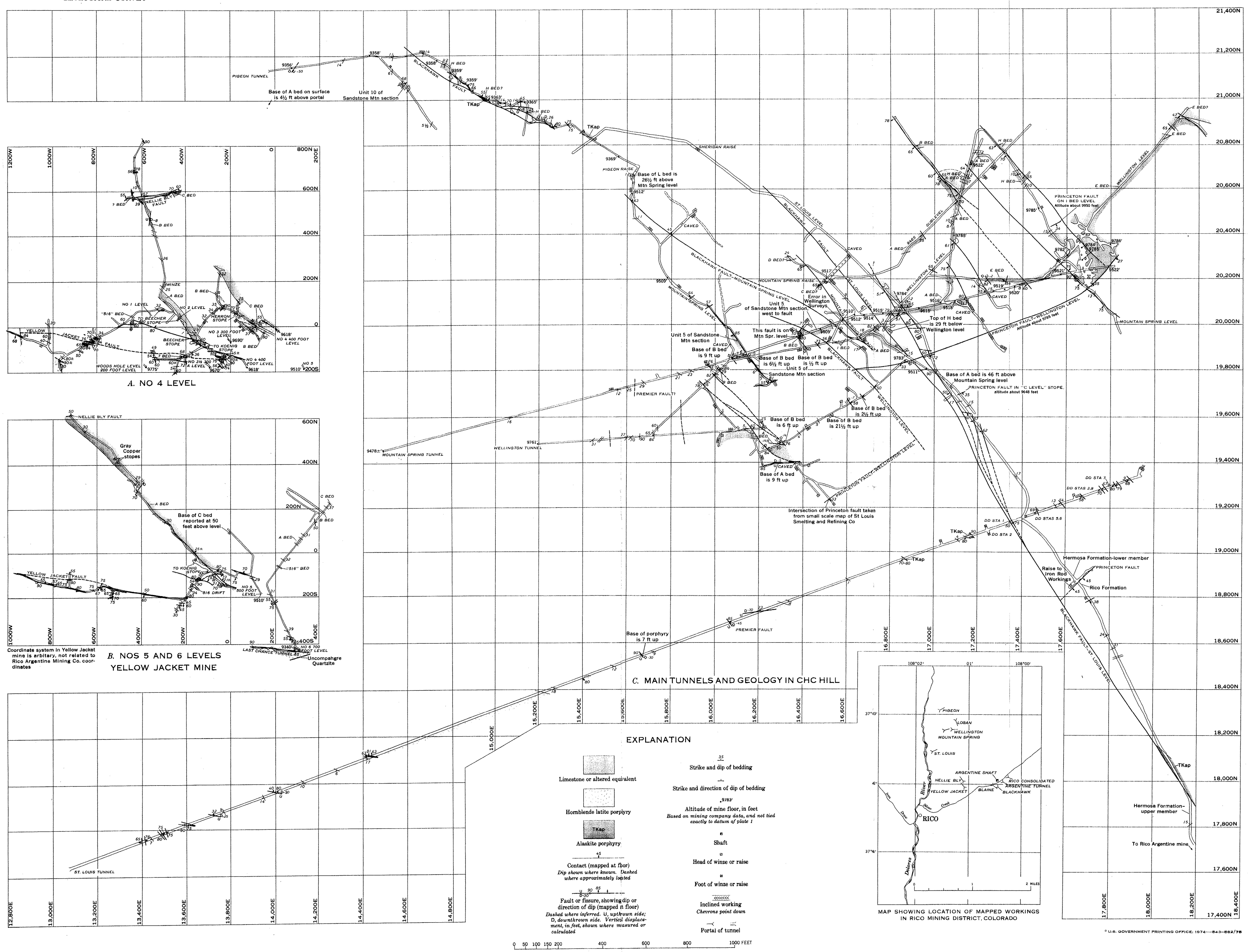
13-Photographs

14-Mine Maps

5-017

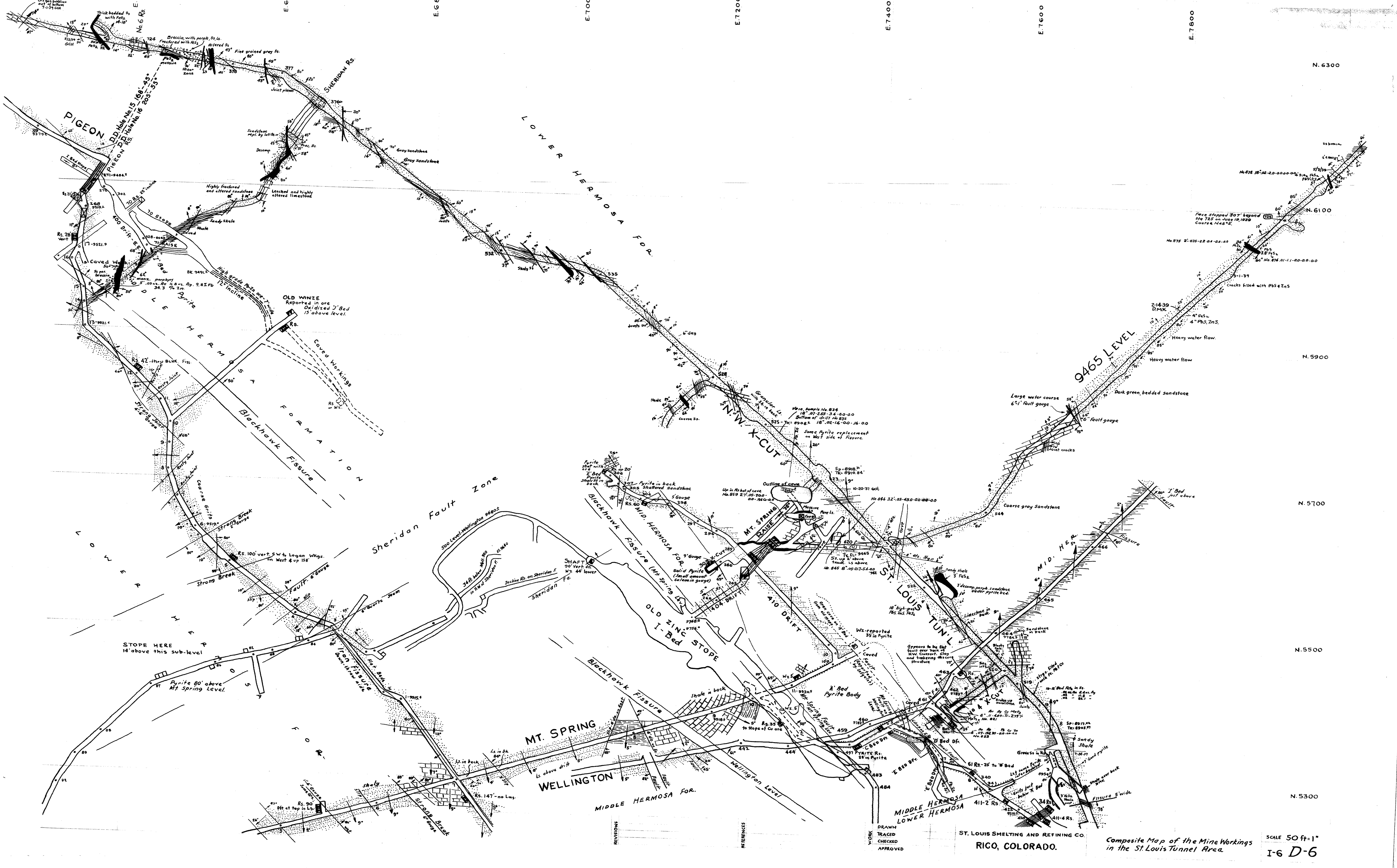
GENERAL SECTION
ALONG BLACKHAWK FAULT
Looking NE
Scale
0 400 800 1200 1600
TELESCOPE MTN.
BLACKHAWK PEAK
Elev 11,985 ft
11,000
10,000
9 000
SECTION SHOWING MINE WORKINGS
PROJECTED ON A S35½°E VERTICAL PLANE
THRU END OF WELLINGTON TUNNELL
JANUARY 1953
SCALE
0 400' 800' 1200' 1600'
WELLINGTON-
MT. SPRINGS
WORKINGS
SILVER CREEK
ARGENTINE WORKINGS
PROPOSED EXTENSION
DOLORES RIVER GRADE
ST. LOUIS WORKINGS

WELLINGTON
Blackhawk Fiss.
MT. SPRING
Princeton Fault
Princeton Fault in top 411-10 Rs. El. 9610
411-10 Rs.
N.W. X-CUT
Blackhawk Fissure
Undine 1090
FORMATION
HERMOSA
LOWER
145 LEVEL
No 1 RAISE
D.D. Sta. 4
D.D. Sta. 1
D.D. Sta. 2
D.D. Sta. 7
Rs. 18'
ST. LOUIS TUNNEL
S.E. X-CUT
IRON ROD SUB. LEV.
Iron Rod Fissure
IRON ROD RAISE
Princeton Fault
N. 55° E.
UPPER HERMOSA
FOR.
Mammoth Loc.
D.D. Sta. 8
D.D. Sta. 9
N. 5100
N. 4900
N. 4700
N. 4500
N. 4300
N. 4100
E. 7400
E. 7600
E. 7800
E. 8000
E. 8200
E. 8400
E. 8600
E. 8800
E. 9000
ST. LOUIS SMELTING AND REFINING CO.
DRAWN
TRACED
CHECKED
APPROVED
SCALE
REVISIONS
REFERENCES
WORK



MAPS SHOWING GEOLOGY OF NOS 4, 5, AND 6 LEVELS OF YELLOW JACKET MINE AND SOME OF THE GEOLOGY IN CHC HILL, RICO DISTRICT, COLORADO

U.S. GOVERNMENT PRINTING OFFICE: 1974—543-882/78


E.6400
E.6600
E.6800
E.7000
E.7200
E.7400
E.7600
E.7800
N.6300
N.6100
N.5900
N.5700
N.5500
N.5300
PIGEON
LOWER HERMOSA FOR.
MIDDLE HERMOSA FORMATION
Blackhawk Fissure
Sheridan Fault Zone
LOWER HERMOSA FOR.
OLD WINZE
Reported in ore
Oxidized 'J' Bed
15' above level.
Caved Workings
N.W. X-CUT
9465 LEVEL
ST. LOUIS TUN'L
MT. SPRING RAISE
OLD ZINC STOPE
I-Bed
404 DRIFT
410 DRIFT
SHAFT
STOPE HERE
14' above this sub-level
Pyrite 80' above
Mt. Spring Level.
Iron Fissure
Blackhawk Fissure
MT. SPRING
WELLINGTON
Wellington Level
MIDDLE HERMOSA FOR.
Strong Break
'A' Bed
Pyrite Body
Heavy water flow.
Dark green, bedded sandstone
Coarse gray Sandstone
MIDDLE HERMOSA
LOWER HERMOSA
Fissure 5' wide
REVISIONS
REFERENCES
WORK
DRAWN
TRACED
CHECKED
APPROVED
ST. LOUIS SMELTING AND REFINING CO.
RICO, COLORADO.
Composite Map of the Mine Workings
in the St. Louis Tunnel Area
SCALE 50 ft=1"
I-6 D-6

WELLINGTON MINE
ST. LOUIS SMELTING AND REFINING CO.
RICO, COLO.
Scale ~ 1in. = 50ft.
March, 1929
A.J. Yahn
Note:- Copied from old maps to conform with coordinate system of Mt. Spring maps. Old maps are not reliable and give no elevations, but most of these workings are now inaccessible for resurvey. Nearly all notations are entirely from hearsay.
Logan Shaft
Logan Workings
Wellington Adit
400 Level
Portal Elev. rail 9761.2
Zinc (I-bed) Stope
Line of Section
Mt. Spring Fault
Shaft down 90' rail. To 500 Level - Wz. 44' lower
To Mt. Springs Workings
Inclined Raise on Sheridan Fault
On Sheridan Fault
Blackhawk Fiss.
Supposed Black Hawk Fiss.
C Bed
Iron Fissure & Fault
Solid Pyrite
A-bed Stope
Princeton Fault projected from 425' Drift
Princeton Fault
Blackhawk Fissure
BLACK SHALE
FAULT
"I" bed lies next above this S.S.?
from face 300' to point under Leap Year Fissure & dip to East Approx 450 ft.
50' Scale Looking N.W.
Pyrite A-bed
Inaccessible
Shaft
N 5900
N 5800
N 5700
N 5600
N 5500
N 5400
N 5300
N 5200
N 5100
N 5000
N 4900
N 4800
N 4700
N 4600
N 4500
N